APR 11 1929

POWER

Power Generation, Transmission, Application and Attendant Services in all Industries

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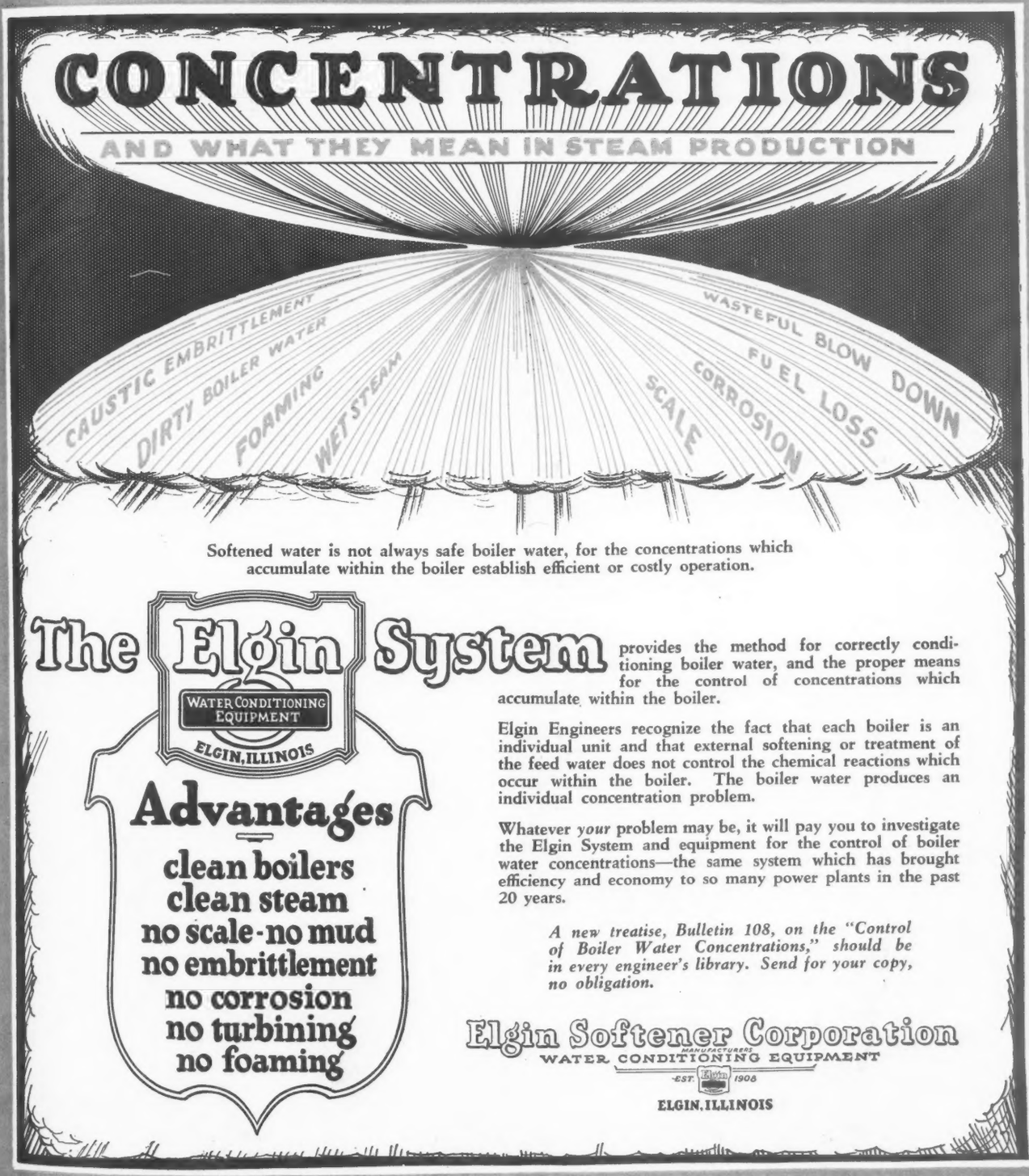

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POWER

With which are consolidated *The Engineer* and the *Stationary Engineer*

Volume 69 Number 15

April 9, 1929

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McGRAW-HILL PUBLISHING COMPANY, INC.
Tenth Ave., at 36th St.
NEW YORK, N. Y.
Cable Address: "Machinist, N. Y."

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Construction Methods
Electrical West
American Machinist—European Edition

SUBSCRIPTION PRICES: United States and its possessions, Canada, Mexico, $3 a year. Central and South American countries, $5 a year. All other foreign countries, $8 a year. Single copy, 15 cents. Published weekly. Entered as second-class matter, December 20, 1910, at the Post Office, New York, N. Y., under the act of March 3, 1879. Printed in U.S.A.

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CHANGE OF ADDRESS
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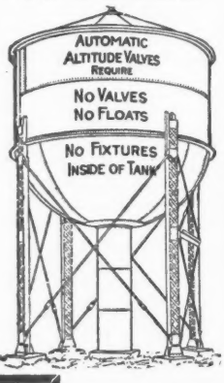

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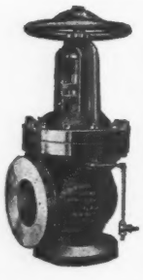

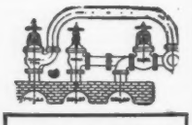

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8. Double Corliss dashpot that cushions in opening and closing.
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2. Operated by protected, enclosed copper float.
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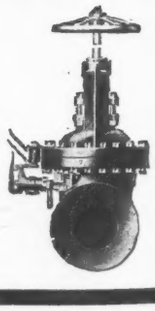

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POWER

FRED R. LOW, *Editor*

Irving Fellner
Publishing Director

Volume 69 New York, April 9, 1929 *Number 15*

Science and Practice

A NICE chart of the territory that he was entering would be a fine thing for an explorer to have.

The trouble is that the country has to be explored before it can be charted.

The chart is an excellent aid to organization and development and, when done on broad lines, may be helpful in further detailed exploration.

How easy and more rapid the development of steam engineering would have been if the pioneers like Papin, Newcomen and Watt had had our knowledge of the nature of heat and the properties of materials.

They did not. But they made engines that ran and improved them until they became the basis of this industrial age.

And then the physicists found that heat was not stuff but a made of motion, and Carnot and the others mapped out the laws of its transformation into useful forms of power.

I have a great admiration for those master minds that follow heat into the intricacies of molecular physics and, like an airman, see the subject in its entirety and in its details and can direct the worker how to go and point out the limits to possible progress in any direction.

But I have a warm place in my heart, too, for the fellow who, while the others descant learnedly on heat physics and thermodynamics, goes out and gets an armful of wood when the fire is getting low.

F. R. Low

POWER *Stands for . . .*

1. **Making Power When It Should Be Made**
2. **Buying Power When It Should Be Bought**
3. **Cheaper Power Through Modern Equipment**
4. **Easier Financing of Equipment Purchases**
5. **Better Use of Byproduct Heat and Power**
6. **Operating Methods That Save Money**
7. **Less Waste in Transmission and Application**

Are Power Stations Becoming Too Complicated?

DURING the last eight or ten years remarkable progress has been made toward increased economy in power production in central stations. A reduction in average coal consumption from 3.2 in 1918 to 1.76 in 1928 indicates how well the engineers have succeeded in their task. But as they press further toward this goal the law of diminishing returns is encountered with increased force and the cost of achieving the results goes up. It is true that unit investment costs have been kept within bounds by employing large boilers and turbines, but there is a ratio between system capacity and size of generating equipment that it is not wise to exceed. Moreover, because of the relatively low generating costs at the switchboard, as compared with the total cost of power, executives are now bringing pressure in some quarters toward reduced investment costs.

There is still another angle to the problem, which from the operating standpoint is extremely important. This pertains to complication in design, which has resulted from the strife toward increased efficiency. Such complication adds materially to the operating man's problems and responsibilities, and has resulted in specialization with the power plant itself. Just where to draw the line as to further complication, over-all efficiency and investment costs is a matter to which some designers are now giving thought.

Byproduct Power Determines Industrial Steam Pressures

IN CENTRAL-STATION work the correct pressure to use is that which gives a minimum ratio of total yearly cost to kilowatt-hour output. This simple relation does not hold for the industrial plant.

At present, with low capacity factor and low fuel cost, the 400-lb. central station generally has a slight advantage over the 1,200-lb. station. With somewhat higher capacity factor and fuel cost the 1,200-lb. station seems to show a distinct commercial gain.

Even with low capacity factor and low fuel cost the margin of the 400-lb. station is very small. It is not improbable that within two or three years the excess cost of the 1,200-lb. station will be entirely wiped out, so that the 400-lb. station will have no advantage under any conditions, with a strong trend toward 1,200-lb. Central stations in the range from 600 to 1,000 lb. may be put out of the running, because they cost more to build than 1,200-lb. stations and save less fuel. New developments in reheating might, of course, change this situation.

The correct pressure in industrial plants is fixed by quite different considerations. It is true that a large industrial power plant, operating straight condensing, might determine its pressure on the same basis as the central station, but such plants are rare. In the case of industrial plants with substantial process and power loads, the desirability of generating the power load as a byproduct of the process steam will in general fix the economic pressure. It may easily pay some plants of this type to go to pressures around 2,000 lb., if lower pressures will not generate the power load as a byproduct. An example is the 1,800-lb. Philip Carey installation, now under construction.

Thus, as pointed out in the article on page 581 of this number, a few industrial plants will justify pressures far higher than those that can now be economically carried in central stations. Others will properly fall in the range from 600 to 1,000 lb., where few central stations will be built, according to present indications. Many industrial plants will be built to operate in the 300-500 lb. range. Still others will find the 150-lb. and 200-lb. pressures now generally carried most satisfactory for their purposes.

Production Restriction and Fuel Oil for Boilers

RESTRICTION of the production of petroleum in the Western Hemisphere will probably result from action recently taken by the American Petroleum Institute. This organization, which includes practically all of the petroleum producers of North and South America, has agreed on a basis of curtailment and has forwarded this agreement to the proper governmental bodies for approval.

The basis of the restriction suggested is the amount of oil produced in 1928. This is to be the limit, above which production may not go, for several years; after which a new basis will be taken.

It is considered that this amount will supply sufficient gasoline for automotive needs, as, in the year referred to, only about forty per cent of the oil was turned into motor fuel. New equipment in refineries, with a full use of available cracking processes, permits a much higher gasoline recovery, thus making possible a sufficient supply from an oil production that is stationary for the next three years or so.

While such restrictions will undoubtedly have no adverse effect on the supply of automotive fuel, there is some question about the future availability of oil for

power plant boilers. If the percentage of crude made into gasoline is to increase from forty to sixty, with no increase in total crude, there will obviously be a curtailment of oil available for other purposes.

The result will undoubtedly be an increase in the price of oil for boiler feed. It will be wise to keep this in mind when planning the construction of new power plants in regions where heretofore oil has been a logical choice for firing boilers.

Why Not Simply Society Programs?

THE greatly enlarged activities of some of our National engineering societies in various subdivisions of their fields has complicated the problem of arranging annual meeting programs. To accord full representation to the different groups concerned makes many simultaneous sessions unavoidable. These are objectionable from several angles. Not only do they make for a cumbersome program, but it is practically impossible to arrange such sessions without conflict. Some members have primary interests in more than one branch of the field; others have a primary interest in one and secondary interests in others. Yet simultaneous sessions deny them the privilege of satisfying these interests. Lastly, one of the important objects of an annual meeting is to afford the membership an opportunity to intermingle, to become better acquainted, and to exchange ideas and experiences. Too heavy a program defeats this purpose.

Some of the societies have attempted to solve the problem with regional meetings and the A.S.M.E. has gone a step further by inaugurating annual meetings for certain professional divisions, such as **Fuels**, Machine Shop Practice, Management, and Oil and **Gas** Power. These meetings have exceeded all expectations, and their success would seem to warrant the idea being applied to other divisions.

However, in spite of these, the demand upon the annual meeting program continues unabated. Some seem obsessed with the idea that presentation at an annual meeting of the Society accords a paper special distinction. As a matter of fact, a paper in a specialized field is more likely to receive the attention due it from the people most concerned at the Divisional Meeting. Again, the demand for full program representation may be actuated by fear on the part of divisional committee members that other divisions will receive more than their share.

Someone recently suggested that the professional programs at the annual meetings of the A.S.M.E. be limited either to papers of general membership interest or to one paper from each professional division and that the remainder of the time be given over to committee meetings, membership contacts, excursions and social events—an idea that undoubtedly would meet with general approval. This is the season for making up the annual meeting program. Why not begin now. The matter will have to be faced sooner or later.

Replacing Obsolete Equipment

WHEN to replace obsolete equipment is a problem that almost every engineer has faced. The answer is not always clear and is influenced by many conditions. Not infrequently equipment is obsolete when it first goes into operation, due either to misapplication, to radical changes in design or to some other cause. On the other hand, certain equipment has little likelihood of becoming obsolete for the service and conditions to which it is applied.

In the final analysis, economic considerations reduce the problem of replacing equipment to the simple statement, "Will it pay to make the change?" This formula for making the change involves many factors such as increased production, reduced maintenance and labor costs, increased efficiency of the drive, improved working conditions, increased safety and many other considerations. High maintenance costs are not given the weight that they should be. Too frequently these costs are consolidated for the whole plant and those for the individual pieces of equipment are overlooked.

Motors that are properly applied may never become obsolete, but misapplications may justify replacement at an early period. Overmotoring is a common form of misapplication. Many motors are continuously operating at less than fifty per cent of their normal rating. With induction motors this is undesirable as both the efficiency and the power factor are low. Where power is purchased and the rate contains a power-factor clause, low power factor of the motors may increase the power costs more than low efficiency. It generally will pay to replace such motors with those of the proper size and send the old ones to the second-hand dealer or store them as spares.

Recent developments in induction motors have made possible replacing older types with equipment that is greatly simplified. With the old-type general-purpose motors it was customary to use reduced-voltage starting on sizes above five horsepower. Modern designs are available up to thirty horsepower capacity that are reguarly started by connecting directly to the line. The simple construction of these new motors and their starting equipment places a new aspect on the question of when does it pay to change old motors for new.

"WHY is a carefully designed and delicately adjusted governor used on the turbine generator, while hand regulation persists in the boiler room?" The question was asked at a recent engineering meeting. Historically, the answer is simple enough. From the very first, turbine generators have been equipped with governors because simple hand control is unthinkable. The boiler room *can* get by without automatic regulation. However, the proof that mechanism is more reliable than men is rapidly displacing hand control all over the plant. Undoubtedly, the day is fast approaching when all normal power-plant regulating operations will be automatic, leaving only exceptional adjustments to be taken care of by the plant personnel.

Choosing Silent Chains to

By F. A. ANNETT
Associate Editor, *Power*

Slow-speed motors directly connected to their load are compared with high-speed types driving through silent chains. The conditions for which chain drives are suited are given and the factors that influence their successful operation are outlined.

SIMPLIFICATION of power drives and increased efficiency have been outstanding factors in the development of modern applications. Electrification of industry ushered in a new era in power transmission and application. Previous to this, power was transmitted largely by belts, gearing, shafts and counter shafts from a steam engine or a water wheel. This system of transmission and application was complicated, unsightly and inefficient. Much of the transmission equipment had to be kept in operation when it was not needed, consequently the power losses were high even when the equipment was kept in good condition. But, due to shafting being out of line, belts too tight or too loose, gears not properly meshed, lack of lubrication in bearings, worn bearings and to many other causes the power losses in the old systems were frequently excessive.

The introduction of individual motor drives allowed eliminating a great deal of the old system of power transmission equipment and created a need for simple and efficient means of connecting motors to their load. When motors operating at efficient speeds can be coupled directly to the drive shaft of the driven machine, or group of machines, this method of driving machines is generally the most satisfactory.

Electric motors are most efficient when operating at relatively high speeds, furthermore high-speed motors have smaller dimensions than slow-speed machines and cost less for a given output. The power factor of high-speed induction motors is much higher than for slow-speed types, which is an important feature, particularly if power is purchased. In general, relatively high-speed motors have lower maintenance costs than slow-speed machines. Consequently, for a large percentage of drives that require low-speed at the drive shaft, a high-speed motor with some form of speed reducer offers the best solution. Among the forms of speed reducers that have come into wide use are silent-chain drives. The following are some of their characteristics:

1. They can be operated at relatively high speeds in either direction and in any position between horizontal and vertical.
2. They are not affected by heat, cold or moisture, will transmit power up to their breaking strength and give a positive speed ratio between the driving and the driven shaft.
3. They can be used on short-center or on comparatively long-center drives, operate with practically no tension in the slack side, consequently, bearing friction is maintained at a low value for given load transmitted.
4. When properly installed and maintained they operate quietly, have a high efficiency and low maintenance cost.
5. They do not transmit vibration from the driven machine to the motor shaft and bearings, and, although providing a positive drive between the motor and driven machine, they possess a certain elasticity that helps to

Fig. 1—Induced-draft fan connected to 150-hp. motor by silent chain

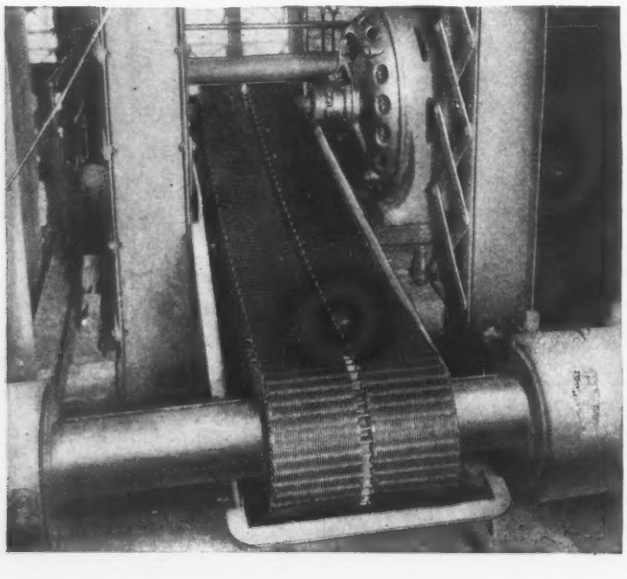
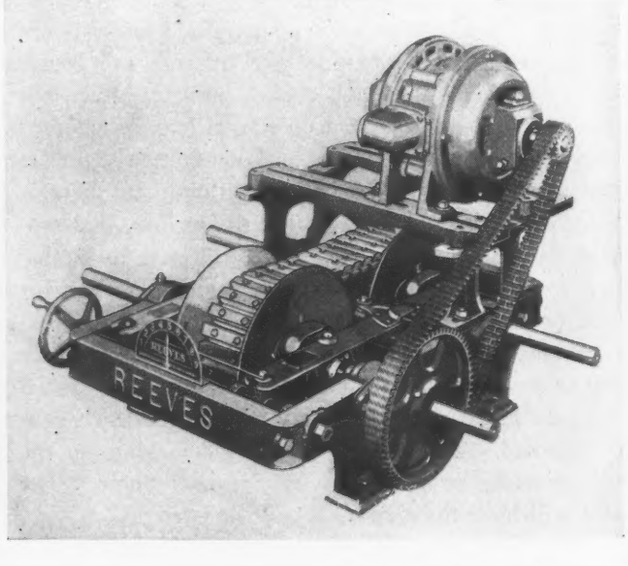


Fig. 2—Silent chain connects motor to variable-speed transmission



ns to Suit the Drive

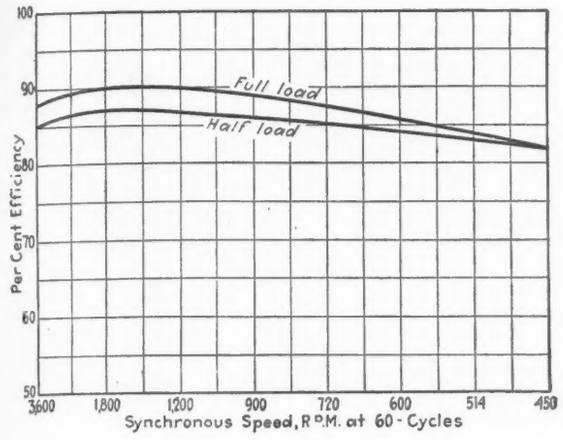


Fig. 3—Efficiencies of 15-hp. 60-cycle squirrel-cage motors at different speeds

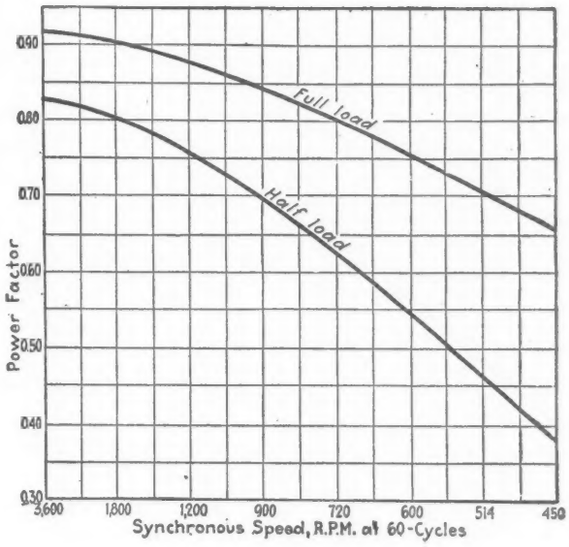


Fig. 4—Power factors of 15-hp. 60-cycle squirrel-cage motors at different speeds

relieve load shocks, such as may be experienced under certain conditions with direct coupling.

Fig. 3 gives the full-load and half-load efficiencies of a line of 15-hp. 60-cycle induction motors ranging in speed from 3,600 r.p.m. to 450 r.p.m. These curves show that the high-speed motors have a decided advantage in efficiency over the slow-speed types. For example, the 1,800-r.p.m. machine at full-load has an efficiency of about 90 per cent, compared to about 82 per cent for the 450-r.p.m. motor. The difference in power factor is even more impressive than the difference in efficiency, as indicated by the curves, Fig. 4. At full load the power factor of the 1,800-r.p.m. motor is about 0.91 and that of the 450-r.p.m. machine 0.66. Power-factor values for these machines at one-half load are about 0.81 and 0.38 respectively.

Silent chain drives when properly installed and maintained have an efficiency of 98 per cent or better. Therefore, when used with a high-speed motor, the combination will have a better efficiency than the slow-speed motor directly connected to the load, and the power factor will be considerably higher. The difference in cost will be in favor of the high-speed motor with a silent chain drive. This comparison should not be taken as something that is applicable to all cases. Local conditions present many factors that must be considered when selecting drives.

Even though silent chain drives have been developed to a high state of perfection, they, like belts, gears or any other power transmitting equipment, must be prop-

Fig. 5—Two chain drives connect 300-hp. motor to mine hoist

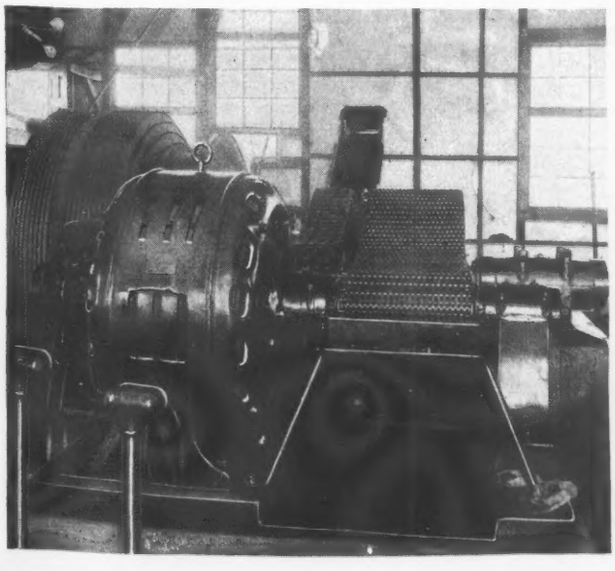
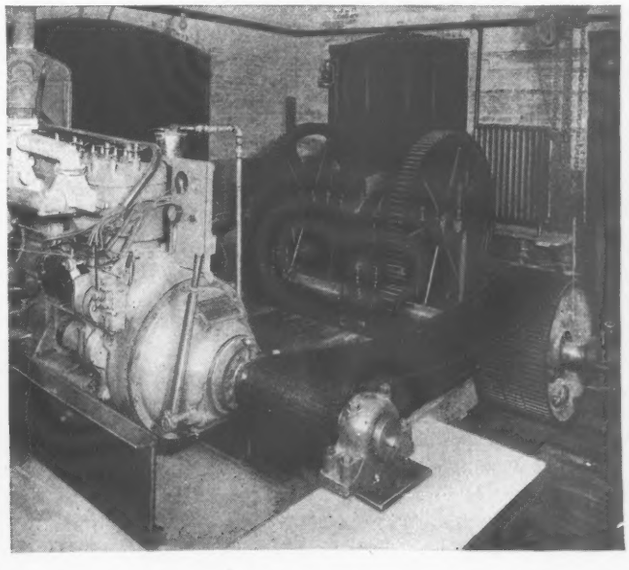


Fig. 6—Triplex pump driven from 100-hp. gas engine by silent chain



erly applied, installed and maintained. These drives are not suited to every possible service, but there is a wide range of applications where they are successfully used. They are not suited to excessively short-center nor very long-center drives. Silent chain drives have been used on the same centers as gears, but this was done by using small sprockets. Loads that impose severe vibration and shocks on the drive should be looked into carefully before applying a silent chain. A flywheel applied to the load or the use of a spring sprocket will relieve the chain from at least part of the shock.

Chain drives have been built in a size range from those that drive a sewing machine head to one of 5,000-hp. rating. Chain speeds up to about 5,000 ft. per minute have been used, but the most desirable speed is around 1,200 to 1,500 ft. per min. As the speed decreases the power output of a given chain decreases and the cost increases. For this reason it is not, in general, desirable to use a chain speed below about 1,000 ft. per min. Standard drives in the smaller sizes are listed down to about 600 ft. per min. At speeds higher than 1,500 ft. per min. the chain should be encased to insure proper lubrication. Also, where abrasive dusts and corrosive fumes are present, the chain should be encased to protect it against the action of these materials.

Among the factors influencing the selection of a chain are the power to be transmitted and the speeds of the driving and the driven shafts. When selecting a chain one of the first things to determine is the proper pitch. One manufacturer lists chains in ten different standard pitches ranging from $\frac{1}{8}$ to 3 in. in length, for chain widths from $\frac{1}{8}$ to 30 in. Where greater capacity is required to transmit the required power a chain having more than one strand is used. These chains operate on

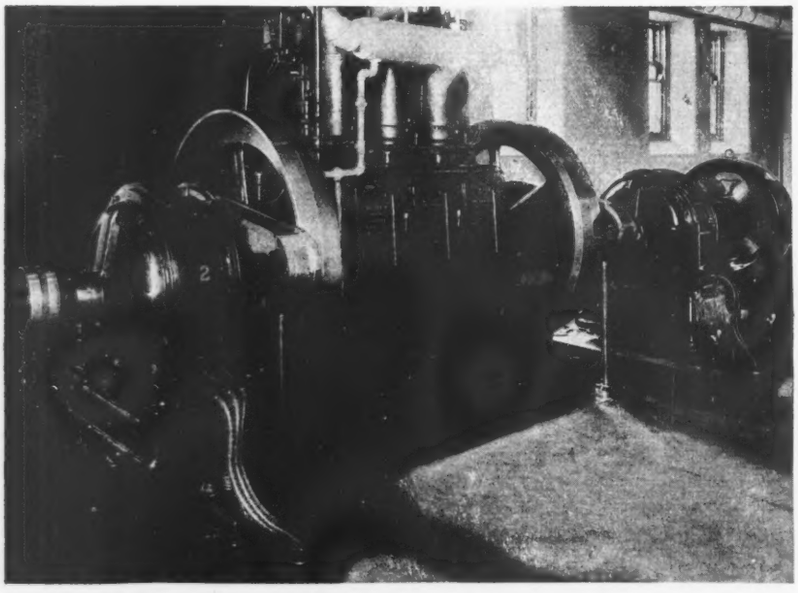


Fig. 7—Generators driven from each end of an oil-engine crankshaft by silent chains

sprockets that have from 13 to 130 teeth. For small and moderate powers, the smaller pitches are best suited; for the large chains the longer pitches are desirable.

In most cases it is preferable to use teh largest pitch possible without exceeding the maximum allowable speed for that pitch. The amount of power to be transmitted has an influence on the pitch to use. When the power

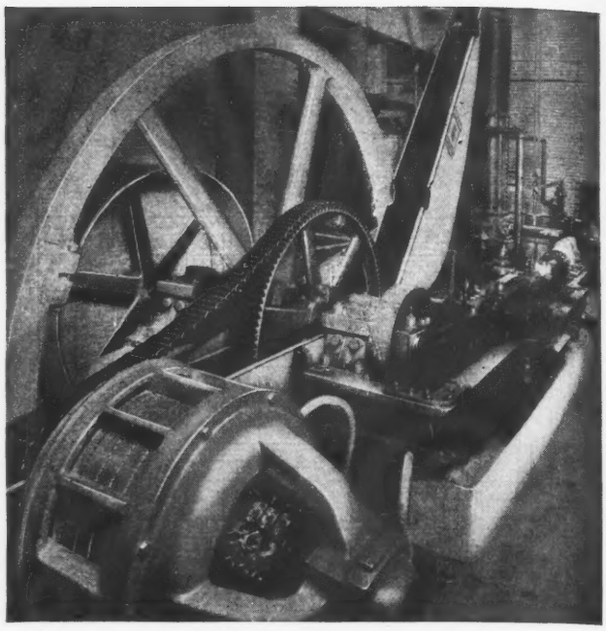


Fig. 8—Motor drives high-pressure pump through silent chain

This pump was originally driven by a steam engine. The steam cylinders were removed and a 50-hp. motor connected to the crankshaft by a chain drive.

transmitted is small, it may be found that a very narrow chain will be required if a pitch is used that is considered best suited to the rotative speed. For this reason it is sometimes preferable to use a smaller pitch than would ordinarily be adopted.

The width of the chain is a good check on the pitch, when the chain design has been worked out. A very narrow chain indicates that the pitch selected is too large, and too wide a chain might show that a larger pitch should be used. The latter of course is controlled to a considerable extent by the power that must be transmitted. Obviously it is impractical to design a narrow chain for large power.

Where quiet operation must be considered, it will be found that a chain with the smallest pitch that will drive the load will be the best suited. Experience has shown that at a given lineal speed, the smaller the pitch the more quietly the chain will operate.

It is recommended that an odd number of teeth be used in both sprockets when possible. Regular practice is to furnish chains with an even number of pitches (links) run on sprockets with an odd number of teeth. This combination gives the best operating drive and the most satisfactory from a mechanical standpoint. If an even number of links is used, then, what is known as a hunting link will be required to join the two ends of the chain. This link is of a special construction and is best avoided wherever possible, if for no other reason, it requires special parts for replacements.

The number of teeth used in a sprocket should not be less than fifteen. For motor pinions and for speed ratios between 3 to 1 and 5 to 1, the number of teeth generally used is 17, 19 or 21. Where speed ratios from 5

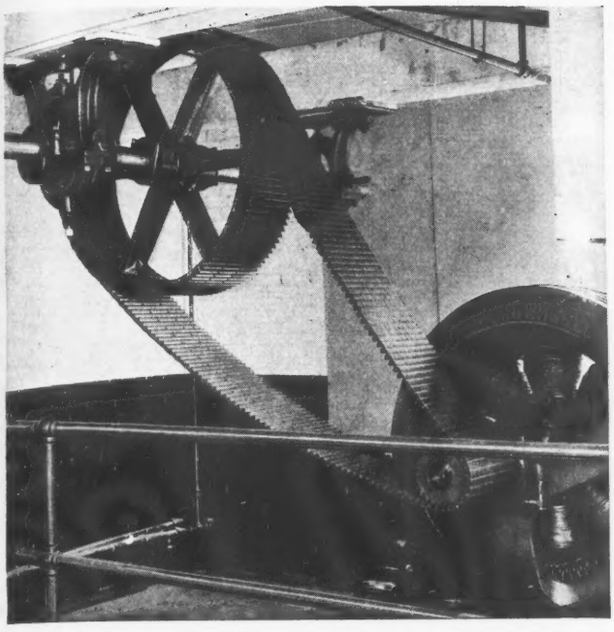


Fig. 9—Generator driven by 100-hp. silent-chain drive from line shaft

to 1 to 6 to 1 are requred 17 teeth are recommended. Above a speed ratio of 6 to 1, a pinion having 15 teeth will generally give the best results, except for 1.2-in. pitch and up, 17 teeth is the minimum number. The most desirable speed ratios are 1 to 1 to 7 to 1, but ratios of as high as 15 to 1 have been used.

Experience has shown that about 130 teeth is the maximum that should be used in the large sprocket and better results will generally be obtained with a smaller number, particularly so with the smaller pitches. With small speed ratios, the drive should be designed to obtain at least 33 teeth in the driven sprocket. Often when the ratio is around 1 to 1, it may be necessary to reduce the pitch of the sprockets so as to get more teeth without increasing the speed of the chain. The determining factor is to try and choose a sprocket that will not give a chain speed much above 1,200 to 1,400 feet per minute.

The chain speed in feet per minute may be determined by the formula:

$$\textit{Feet per minute} = \frac{T \times S}{N},$$

where T equals the number of teeth in either sprocket; S the speed of this sprocket in revolutions per minute; and N the number of sprocket teeth per foot of chain.

In the foregoing no attempt has been made to work out the complete design of a chain drive. The points brought out show that such designs require careful consideration if the most satisfactory selection is to be had. In this respect chain drives do not differ from other equipment. The manufacturers furnish comprehensive data and instruction books from which designs can be made, and those having to select such drives will do well to avail themselves of this literature, or submit their problems directly to the manufacturers.

Although silent chain drives have been developed to a high state of perfection, they, like belts or gears, must be properly applied, installed and maintained if they are to render a full measure of service. The shafts on which the sprockets are mounted must be parallel. These shafts must be held in bearings that will not permit them to weave or pull out of line. For the benefit of the motor as well as for the satisfactory operation of the chain drive, the motor must be securely supported on a substantial foundation.

The faces of the two sprockets must be in alignment. Where the motor shaft can float it is generally best to intsall the sprocket on this shaft so that it will be in a central position of the floating motion, unless it is found that the shaft runs in some other position. This can be determined after the drive has been put into operation. How well the sprockets are aligned can generally be checked by the wear on the chain's guide links. If these links wear on one side, it shows that the drive is not properly aligned.

The amount of slack that can be allowed in a chain depends upon a number of factors. If the motor is on a sliding base, its position should be adjusted so that there is only a small amount of slack in the chain. If no adjustment is possible, then the chain should be installed so that there is a minimum amount of slack. If the load is constant and the chain runs in a position of less than 45 deg. to the horizontal, considerable slack in the chain may not interfere with its satisfactory operation.

A chain drive may run with the slack on the top or on the bottom, unless the center distance between the sprockets is short, in which case it is preferred to have the slack on the bottom. On very short-center drives with the slack on top, there is a tendency for the slack to be pushed out of proper engagement with the teeth of the driven sprocket. Where the distance between centers is long and the sprockets are small the slack should be run on the bottom. If the slack is on the top, there is danger of the upper strand rubbing on the bottom and injuring the drive.

Wherever possible, vertical drives should be avoided. To keep the chain in proper mesh with the lower pinion, it must be run under a slight tension. To maintain this tension requires frequent adjustment to compensate for the natural wear of the chain. These difficulties can be avoided by placing the drive slightly off the vertical. Drives, the center line of which approaches the vertical, should be run with the slack in the side that makes the smallest angle to the horizontal.

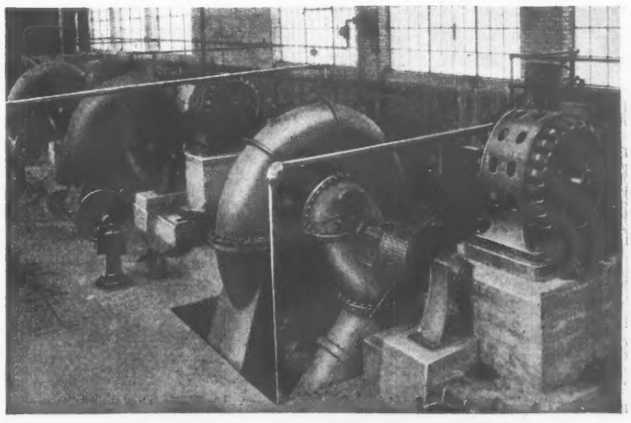


Fig. 10—Motors rated at 240 hp. connected by silent chains to centrifugal pumps

The author acknowledges with thanks the assistance rendered in the preparation of this article by the Morse Chain Co., Ramsey Chain Co.; Link-Belt Co.; Union Chain & Manufacturing Co.; and Reeves Pulley Company.

A Résumé of

HIGH STEAM PRESSURES

In the

INDUSTRIAL PLANT

By P. W. SWAIN
Associate Editor of Power

FIVE years ago the subject of high steam pressures held only an academic interest for the average engineer. Today that interest has become intensely practical. Experimental and commercial plants carrying pressures up to 1,200 lb., and even higher, have fully realized the economies predicted from theoretical considerations, while troubles encountered have been relatively unimportant or easily overcome.

The early initiative in this development was taken by European engineers. Such daring innovations as the Benson system of steam generation at the critical pressure (3,200 lb.), the Atmos rotating-tube boiler and the "steam pumping" boiler of Professor Loeffler (Charlottenburg, Germany), all of which are now exemplified by commercial installations, have at least done much to set American engineers thinking in a practical way of the possibilities of high pressures.

In the American development great credit is due to George Orrok, who some years ago showed clearly that existing materials and design data were adequate to cope with high-pressure problems and that 1,200-lb. pressure offered the possibility of commercial savings. Mr. Orrok was also one of the first to gain general acceptance for the view that temperature rather than pressure is the limiting factor with existing materials.

But even Mr. Orrok's clear analysis of the situation did not convince the average engineer that 1,200-lb. pressure was worthy of practical consideration. That required the work of another pioneer, I. E. Moultrop of the Edison Electric Illuminating Company of Boston. Mr. Moultrop sponsored the first large commercial high-pressure installation in America at the Edgar Station. The Edgar 1,200-lb. installation (super-imposed on a lower pressure) developed some trouble, much of which was not inherently due to high pressure. The installation, which has been enlarged several times, is now officially recognized as successful. This pioneer 1,200-lb. installation was followed by others at Milwaukee and Kansas City. At the present time several other 1,200- or 1,400-lb. central-station installations are going in or being considered, notably the Holland (New Jersey) Station, the first designed exclusively for 1,400-lb. pressure, the new Deep Water (New Jersey) plant, which will have a process tie-in with the neighboring Du Pont manufacturing plant and another 1,200-lb. project recently announced by the Pacific Gas and Electric Company.

This paper, which was presented before the Philadelphia section of the A.S.M.E. on March 26, shows that the possibilities of byproduct power justify a wide pressure range in industrial plants. For lack of space it is necessary to omit comments received from manufacturers and a table, prepared by the author, of nearly 140 industrial plants operating at pressures ranging from 300 to 1,800 lb. It is planned to publish this table, enlarged and revised, in the May 28 number of Power.

In America the central stations have been continually in advance of the industrial plants in the matter of pressures, pioneering at every stage as pressures have grown from 100 to 200, 300, 400, 500, 600 and now to 1,200 and 1,400 lb. This leadership was natural since the central stations, devoted entirely to large-scale power production, and with enormous financial and engineering resources, could afford the cost and risk of development work. An exception to the previous statement must be made in the case of the 1,800-lb. Philip Carey installation now under construction. This pressure exceeds that of any existing or projected central stations.

So far I have not even defined high pressures. A definition would appear to be needed when an industrial plant engineer will speak of his "high-pressure" boilers, meaning 250 lb., while the central station man will refer to a 400-lb. station as "low-pressure." It is, of course, with apologies to Einstein, entirely a matter of relativity.

At present it is perhaps best to define high pressure

as a pressure high enough to be something out of the ordinary. On this basis 600 lb. and up is high pressure for central-station work and 300 lb. and up for industrial plants. But, while industrial plants above 300 lb. are the exception, they are not at all uncommon. Even at 400 lb. and above there are at least 70 industrial plants in the United States and Canada and probably many others not yet tabulated. However, for the purposes of this survey I have arbitrarily fixed a lower pressure limit of 300 lb.

Before turning entirely to the industrial plant, attention should be called to a very marked distinction between the industrial plant and the central station in the matter of justified pressures. Papers and discussions at recent A.S.M.E. meetings (notably the Pittsburgh Meeting in May, 1928, and the Metropolitan Section Meeting in February of this year) brought out a consensus of opinion about as follows: A 600-lb. plant with reheating will show a 7 per cent saving, approximately, over a 400-lb. plant. A 1,200-lb. plant will show about 13 per cent saving. This refers to fuel only. But strange to say, the 600-lb. plant will cost more than either a 1,200-lb. or a 400-lb. plant. Some say that the 1,200-lb. plant will not cost a penny more than the 400-lb. plant if properly designed, and the average estimate of several authorities is around 5 per cent. As a result the 1,200-lb. plant appears to offer greater commercial economy than 400 lb. for most conditions and to be invariably better than the 600-lb. plant, which costs more and burns more fuel.

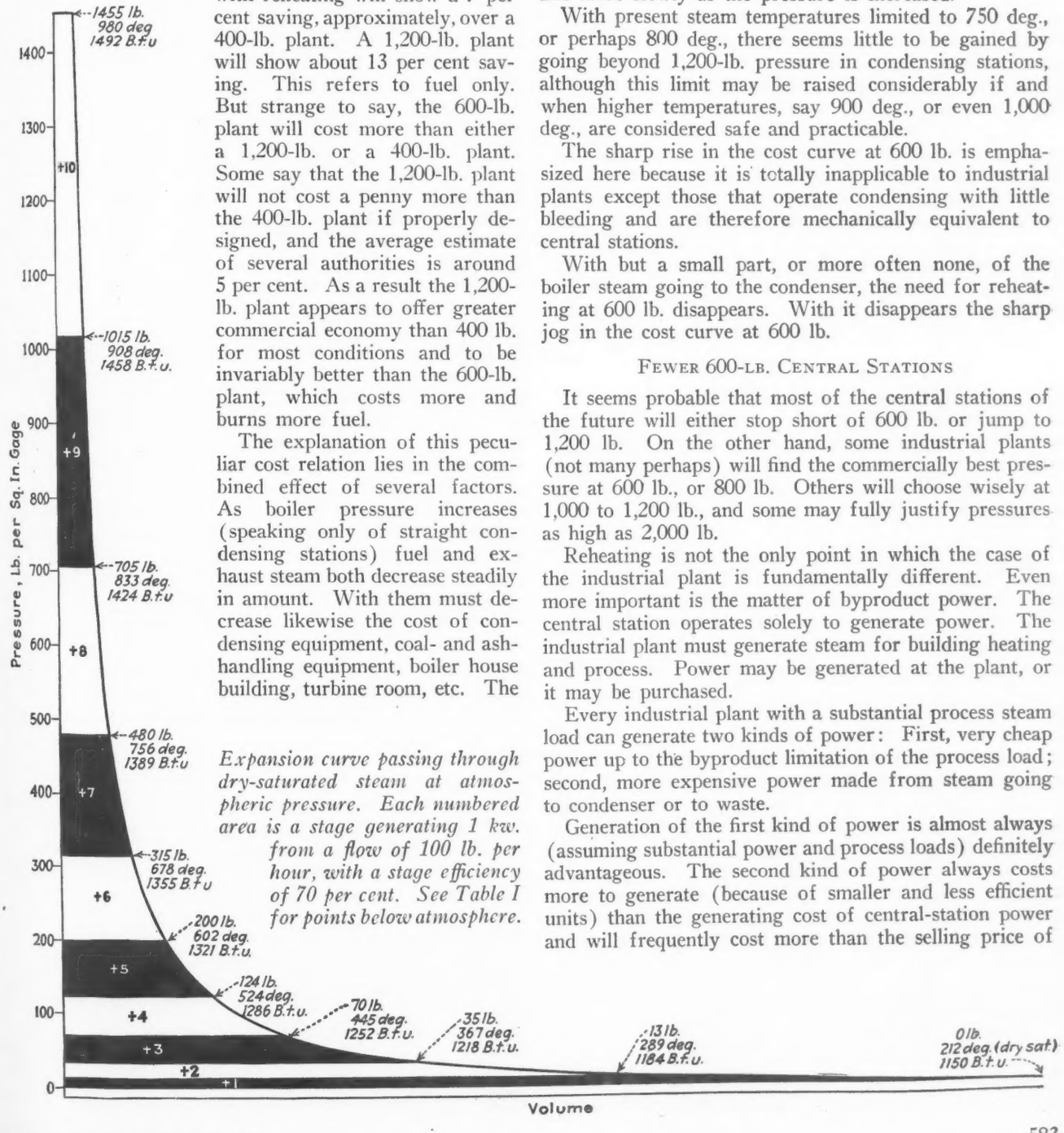
The explanation of this peculiar cost relation lies in the combined effect of several factors. As boiler pressure increases (speaking only of straight condensing stations) fuel and exhaust steam both decrease steadily in amount. With them must decrease likewise the cost of condensing equipment, coal- and ash-handling equipment, boiler house building, turbine room, etc. The cost of the boiler, feed pumps and high-pressure attachments do not increase enough to offset these savings. But at some pressure between 400 lb. and 600 lb., is a sudden upward jog in the cost curve due to the installation of reheating equipment. Initial steam temperatures being, for the moment, fixed around 750 to 800 deg., the higher the boiler pressure the higher must be that point in the turbine where saturation is reached.

All stages beyond the saturation point suffer a serious loss in efficiency from wet steam. Around 500 or 600 lb. boiler pressure the section thus affected is so great that it is necessary to split the expansion into two parts and reheat between, using a reheat boiler or section or a live steam reheater or both. This naturally increases the investment sharply. Beyond 600 lb. the cost again falls off steadily until, at 1,200 lb. pressure, it practically reaches that for 400 lb. The fuel consumption continues to fall off up to 1,200 lb. and beyond, although more and more slowly as the pressure is increased.

With present steam temperatures limited to 750 deg., or perhaps 800 deg., there seems little to be gained by going beyond 1,200-lb. pressure in condensing stations, although this limit may be raised considerably if and when higher temperatures, say 900 deg., or even 1,000 deg., are considered safe and practicable.

The sharp rise in the cost curve at 600 lb. is emphasized here because it is totally inapplicable to industrial plants except those that operate condensing with little bleeding and are therefore mechanically equivalent to central stations.

With but a small part, or more often none, of the boiler steam going to the condenser, the need for reheating at 600 lb. disappears. With it disappears the sharp jog in the cost curve at 600 lb.



Expansion curve passing through dry-saturated steam at atmospheric pressure. Each numbered area is a stage generating 1 kw. from a flow of 100 lb. per hour, with a stage efficiency of 70 per cent. See Table I for points below atmosphere.

Fewer 600-lb. Central Stations

It seems probable that most of the central stations of the future will either stop short of 600 lb. or jump to 1,200 lb. On the other hand, some industrial plants (not many perhaps) will find the commercially best pressure at 600 lb., or 800 lb. Others will choose wisely at 1,000 to 1,200 lb., and some may fully justify pressures as high as 2,000 lb.

Reheating is not the only point in which the case of the industrial plant is fundamentally different. Even more important is the matter of byproduct power. The central station operates solely to generate power. The industrial plant must generate steam for building heating and process. Power may be generated at the plant, or it may be purchased.

Every industrial plant with a substantial process steam load can generate two kinds of power: First, very cheap power up to the byproduct limitation of the process load; second, more expensive power made from steam going to condenser or to waste.

Generation of the first kind of power is almost always (assuming substantial power and process loads) definitely advantageous. The second kind of power always costs more to generate (because of smaller and less efficient units) than the generating cost of central-station power and will frequently cost more than the selling price of

central-station power, which includes profits and transmission losses and overhead.

Assuming the availability of suitable high-pressure equipment (which is now assured) and competent operating personnel (which means that the plant must be large enough to afford a good engineer), the plant with large process load can almost invariably justify running up the initial pressure to the point where the body of the power load can be generated as a byproduct. It may pay to generate the peaks, or it may be cheaper to buy part of the power. Again it may pay best to use a condensing bleeder turbine, generating the mass of the power demand as a byproduct and carrying the upper portion and peaks from the more costly "condensing" power.

Endless Combinations Possible

Endless combinations are, of course, possible, as the study of existing plants shows. A simple turbine may exhaust to process. It may exhaust to low-presure heating or process and be bled at one or several points. The bled steam may go to process or to low-pressure generating units or both. The low-pressure units may exhaust to condenser or to process. With all of these combinations part of the power may be purchased. In some cases even arrangements have been made to exchange power with central stations, buying when the ratio of power to process demand is low and selling when it is high. This arrangement should become more common in the case of large process mills that can offer enough energy (and so timed) to make the arrangement attractive to the central station.

While the central station generally warrants more refinements and a more complex design, the industrial plant offers a far greater diversity of conditions, so that there is less chance to copy and a greater field for original creative work by the designing engineer.

In this work the only safe and absolute method is to figure out the total cost of all power services with various set-ups and pick that which gives the lowest total cost. Power cost alone can be figured as the difference between the total cost with a given power set-up and the total cost of producing process steam alone.

In making this comparison, strict analysis would require figuring the cost of producing process steam alone on the basis of a plant designed for that sole purpose.

The Mollier or total-heat entropy diagram, so essential to the turbine designer, is a very helpful tool for anyone who wishes to study the effect of initial and final pressures on thermal efficiency and on the power available from a given flow of steam.

Expansion Curve Shows Power Obtainable

From the high-pressure Mollier chart recently prepared by Professor Keenan for the A.S.M.E. I have worked out the expansion of steam in a series of steps or "stages." The adiabatic heat drops in each stage is taken such that, with a stage efficiency of 70 per cent, the stage will produce one kilowatt-hour from each 100 lb. weight of steam passing through the turbine. The steps were plotted up and down from dry saturated steam at atmospheric pressure.

The reader should not confuse this with an attempt at turbine design. It is merely a device to illustrate in a general way the effect of changes of initial and final pressure. For this purpose these steps may be looked upon as turbine stages. Turbine efficiencies vary widely with the size and design. The efficiency also varies progressively from stage to stage in a single turbine and falls off sharply when the saturation point is reached. The layout shown, does, however, give some indication of the power actually obtainable from 100 lb. of steam per hour between various pressure limits and is, of course, a much closer indication of the relative power obtainable for different pressure ranges.

Since one kilowatt-hour equals 3,415 B.t.u., the useful heat drop for one kilowatt-hour per 100 lb. of steam will be 34.15 B.t.u. per pound. If this is obtained with a stage efficiency of 70 per cent, the corresponding adiabatic drop will be $34.15 \div 0.70 = 48.8$ B.t.u. and the reheat per stage will be $48.8 - 34.15 = 14.65$ B.t.u.

In practice, with a stage efficiency of 70 per cent, not all of this 14.65 B.t.u. would be returned to the steam as reheat. A fraction of it, perhaps 5 B.t.u., would represent external losses not returned to the steam. Since this correction would have little effect on the conclusions to be drawn, it has been neglected.

Starting at dry saturated atmospheric steam and working up and down in such steps, the following points are obtained:

TABLE I—POINTS ON EXPANSION CURVE

Steps Above or Below Atmospheric	Pressure, Abs.	Pressure, Gage	Total Temp., Deg. F.	Superheat, Deg. F.	Per Cent Moisture
+10	1,470	1,455	980	387	....
+ 9	1,030	1,015	908	360	....
+ 8	720	705	833	327	....
+ 7	495	480	756	290	....
+ 6	330	315	678	252	....
+ 5	216	201	602	214	....
+ 4	139	124	524	172	....
+ 3	85	70	445	129	....
+ 2	50	35	367	87	....
+ 1	28	13	289	43	....
0	14.7	0	212	0	....
— 1	7.4	.....	...	...	2.1
— 2	3.6	.....	...	...	4.3
— 3	1.6	.....	...	...	6.4
— 4	0.7	.....	...	...	8.4
— 5	0.28	.....	...	...	10.4

Volumes have been computed from the pressure and superheat or moisture. The expansion from 1,455 lb., down to atmospheric has been plotted (page 583) as an "indicator diagram." That below atmospheric pressure has been omitted because the enormous volumes involved at high vacua make it impracticable to plot them on the same scale.

On this chart all of the areas (black or white blocks) are equal. Each represents one kilowatt from a flow of 100 lb. of steam per hour with a stage efficiency of 70 per cent. Thus it is clear that the expansion from + 5 (200 lb., 602 deg.) to 0 (atmospheric dry saturated) will yield five kilowatts per 100 lb., or a steam rate of 20 lb. per kilowatt hour. The same expansion continued from 200 lb. to point — 4 (28.5 in., of vacuum) will yield a total of 9 kw.hr. per 100 lb., equivalent to 11.1 lb., per kilowatt hour.

This chart shows the greater relative gain from high pressures as the back pressure is increased. With a back pressure of 0.7 lb. absolute (28.5 in., vacuum) an increase of initial pressure from 200 lb., will increase the power as shown in Table II.

TABLE II—INCREASED POWER PER 100 LB. OF STEAM PER HOUR WITH 0.7 LB. ABSOLUTE EXHAUST PRESSURE

Pressure	Kw., Total	Kw., Increase	Per Cent Increase
200	9	0	0
315	10	1	11
480	11	2	22
705	12	3	33
1,015	13	4	44
1,455	14	5	55

If the back pressure is raised to atmospheric this increase will be as shown in Table III:

TABLE III—INCREASED POWER PER 100 LB. OF STEAM PER HOUR WITH ATMOSPHERIC EXHAUST

Pressure	Kw., Total	Kw., Increase	Per Cent Increase
200	5	0	0
315	6	1	20
480	7	2	40
705	8	3	60
1,015	9	4	80
1,455	10	5	100

In short, the percentage power gain (above 200 lb.) for the non-condensing plant is practically double that for the condensing plant.

With a back pressure of 70 lb. gage the table becomes:

TABLE IV—INCREASED POWER PER 100 LB. OF STEAM PER HOUR WITH 70 LB. GAGE BACK PRESSURE

Pressure	Kw., Total	Kw., Increase	Per Cent Increase
200	2	0	...
315	3	1	50
480	4	2	100
705	5	3	150
1,015	6	4	200
1,455	7	5	250

It should not be assumed that these percentages can be applied directly to get the per cent increase of power obtainable from a given weight of coal. The higher points represent considerably more heat supplied per pound of steam, because of the assumed corresponding increase of total temperature needed to produce dry saturated steam at atmospheric pressure. The heat quantities are shown in the following table:

TABLE V—HEAT IN STEAM AT POINTS ON EXPANSION CURVE

Point	Total Heat	Heat Above 28.5 In. Vac. Total	Heat Above 28.5 In. Vac. Per Cent, Increase	Heat Above Atmospheric Total	Heat Above Atmospheric Per Cent Increase
+ 0	1,150	1,092	0	970	0
+ 1	1,184	1,126	3	1,004	4
+ 2	1,218	1,160	6	1,038	7
+ 3	1,252	1,194	9	1,072	11
+ 4	1,286	1,228	12	1,106	14
+ 5	1,321	1,263	15	1,141	18
+ 6	1,355	1,297	18	1,175	21
+ 7	1,389	1,331	22	1,209	25
+ 8	1,424	1,366	25	1,244	28
+ 9	1,458	1,400	28	1,278	32
+10	1,492	1,434	31	1,312	35

If a straight Rankine cycle is assumed, it is easy to apply Table V to the previous tables to get the actual gain on a heat basis. For example, with atmospheric exhaust, change from 200-lb. initial pressure to 1,455 lb. Then 100 lb. of steam will, in the first case, generate 5 kw.-hr. for 100x1,141=114,100 B.t.u. This amounts to 43.8 kilowatt hours per million B.t.u.

The corresponding figure for 1,455 lb. will be 76.1 kw.hr. per million B.t.u. This shows a net gain in power from a given amount of heat of 74 per cent, whereas Table III shows a 100 per cent gain in the power from a given weight of steam.

It is not necessary to go into this further, because the use of steam at intermediate pressures for feed heating results in still further variation in the power from a given heat supply.

In this detailed study a matter of outstanding importance may be lost sight of. The computation just made of heat per kilowatt hour does not apply at all to byproduct power. It assumes that all of the exhaust heat is thrown to waste except the small portion that is used for heating the feed water to the exhaust temperature. With byproduct power the heat charge is extremely simple. Regardless of the initial or final steam conditions or type of unit, it is merely necessary to charge something more than 3,415 B.t.u. (generally around 4,000 B.t.u. to allow for losses not returned to exhaust steam) for each kilowatt hour. This 4,000 B.t.u. refers to steam. Allowing for usual boiler losses, the corresponding coal consumption will be less than one-half pound per kilowatt-hour even in poorly operated plants with inefficient units. It is a foregone conclusion that the fuel cost of such power will be insignificant. It is hardly worth the trouble of figuring.

Power Needed Fixes the Pressure

What *is* important is how much power is needed and what method of getting it gives the lowest investment cost. There are three ways of getting increased power from a given weight of process steam: Raise the initial pressure; lower the process pressure; use more efficient units. The last includes the electrification of auxiliaries to throw their load back to the more efficient main turbine.

In studying a process plant, the first step, after making sure that no process steam is wasted, is to cut the process pressure as far as can be without affecting the quality of the product or the rate of production. This fixes the exhaust and bleeder pressures and amounts. Then study the effect of electrically driven auxiliaries, higher pressures and more efficient units to see which combination will generate the required amount of power as a byproduct with a minimum investment.

With usual back pressures the initial pressure will be the more important element. When this has been raised to a point where all desired power can be generated as a byproduct (allowing for future increases in the ratio of power to process steam) nothing is to be gained by higher pressure.

This reinforces the statement already made that there is no relation whatever between the proper pressure for a central station and that for a non-condensing or bleeding industrial plant. The central station will stop at 400 or 500 lb., or jump to 1,200 lb. The industrial plant must stop at 300 if that will generate the needed power as a byproduct. The stopping point seems to be about 400 lb. in the paper industry although this naturally varies with the kind of paper, as is illustrated by the case of the Philip Carey 1,800-lb. plant now going in. This plant manufactures a product requiring so much power per 1,000 lb. of process steam that a boiler pressure of 1,800 lb., and highly efficient generating units, are necessary to generate the power demand as a byproduct. I expect to see even higher industrial pressures used in the future in a few cases where the power-process ratio calls for a maximum extraction of power from the steam produced.

[The table presented with the paper in Philadelphia listed four industrial plants in the range above 1,000 lb., four in the range from 600 to 999 lb., and about 63 each in the ranges from 400 to 599 lb. and 300 to 399 lb. This table, with corrections and additions, will be published in the May 28 issue of *Power*. Comments received from manufacturers and operators of high-pressure plants showed a strong trend toward higher pressures and no serious difficulties in the construction or operation of high-pressure plants.—Editor.]

How Power Is Supplied To Electrolytic Processes

When to use rotary converters or motor generator sets; geared-turbine, steam-engine or Diesel-engine driven direct-current generators.

By J. V. Alfriend, Jr.
General Engineer,
Westinghouse Electric and Manufacturing Company

IN THE electrolytic industry the continued growth requires an average yearly world purchase of approximately 200,000-kw. capacity in direct-current machinery. Most of this expansion has been utilized by a normal growth in the electrolytic production or refining of aluminum, copper, nickel, caustic soda and chlorine. With present day refinements in electrolysis of these materials and developments of greatly improved methods for electrolytic production of lead, zinc, hydrogen and oxygen, many old plants must be remodelled, and a large number of new plants will be constructed. This indicates that the yearly increment of installed direct-current capacity will increase sharply in the future.

Power cost including electrical power consumed by the electrolytic cells, electrical losses, and capital charges of the electrical equipment forms a large portion of the value added to the goods in electrolytic plants. For this reason considerable attention should be given to these three components of power cost.

The variables that affect the consumption of power by the cells are beyond the scope of this article. The table gives figures on power consumption based on average conditions. The cost of power at 0.5 cent per kw.-hr. is also included. Where there is more than one product of the electrolysis a market is assumed for all products, and the energy cost is equally divided among them. That is, where there ars 3 products energy is assumed to cost 0.167 cents per kw.-hr. for each product, thus making the 0.5 cent total. This accounting need not be followed as individual conditions may require other methods.

For a complete analysis it is necessary to make a comparison of the cost and performance of the various methods of obtaining direct-current power. These methods are:

1. Purchased or generated alternating-current power converted to direct-current power by:
   A. Synchronous converters.
   B. Motor-generator sets.
   C. Mercury arc rectifiers.
2. Direct-current generation by:
   A. Geared steam-turbine driven direct-current generators.
   B. Steam-engine driven direct-current generators.
   C. Diesel-engine driven direct-current generators.

The synchronous converter and the motor-generator set are by far the most generally used machines for the conversion of alternating current to direct current for electrolytic service. The mercury arc rectifier has not yet been thoroughly tried out for such service in this country, and, therefore, it will not be considered here.

In selecting converting equipment for electrolytic service there are four major considerations that affect the purchase of power:

1. Requirements of the electrolytic circuit.
2. Characteristics of the transmission line.
3. Efficiency of the converting apparatus.
4. Cost of the converting apparatus.

The requirements of the electrolytic circuit usually permit the use of either a motor-generator set or a synchronous converter with or without a synchronous booster or induction regulator, since the required voltage range is usually not greater than 10 per cent plus or minus. If the required voltage variation is much greater than this, a motor-generator set should be used, because of the wide voltage range of a separately excited direct-current generator.

POWER COST FOR DIFFERENT PRODUCTS

Material	Pounds per Kw.-Hr.	Cents per Lb. at 0.5 Cents per Kw.-Hr.
Aluminum	0.1	5.00
Copper-refining	10.0	0.05
Copper-extraction	1.0	0.50
Lead	19.0	0.026
Zinc	0.6	0.83
Hydrogen	0.038 = 6.7 cu.ft.	*6.60
Oxygen	0.304 = 3.35 cu.ft.	*0.82
Chlorine	0.7 = 3.5 cu.ft.	†0.24
Caustic soda	0.8	†0.21
Hydrogen	0.02 = 3.5 cu.ft.	†8.33

*Two products, therefore, power is charged at 0.25 cents per kw.-hr., each.
†Three products, therefore, power is charged at 0.167 cents per kw.-hr., each.

Occasionally the characteristics of the transmission line are such as to cause the motor-generator set to be considered more favorably than the synchronous converter. A long high-voltage transmission line subject to frequent heavy disturbances, which would be reflected through the converter, would cause serious commutator difficulties. This would eliminate the converter from consideration unless the power cost was so high that the

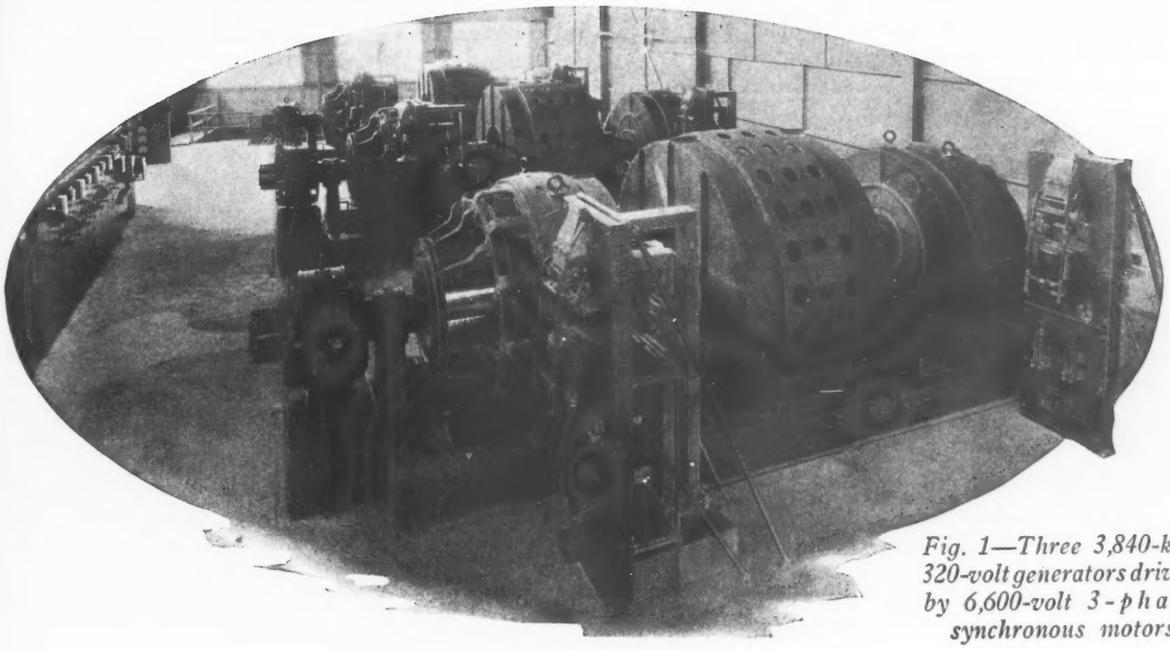


Fig. 1—Three 3,840-kw. 320-volt generators driven by 6,600-volt 3-phase synchronous motors

THESE PLANTS

Supply Power to Electrolytic Processes

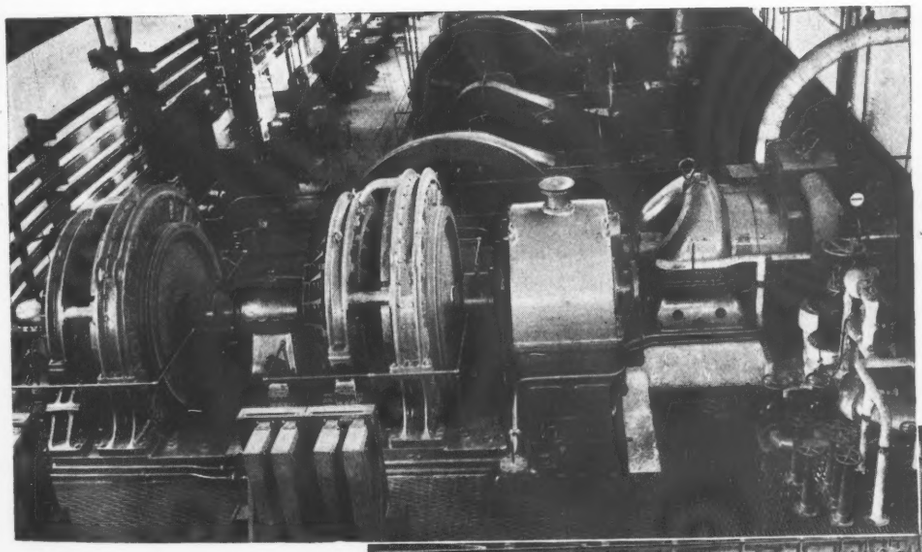


Fig. 2 (Left)—Steam turbine running at 3,600 r.p.m. geared to two 1,400-kw. direct-current generators connected in tandem, through a 10 to 1 single-reduction, single-pinion gear

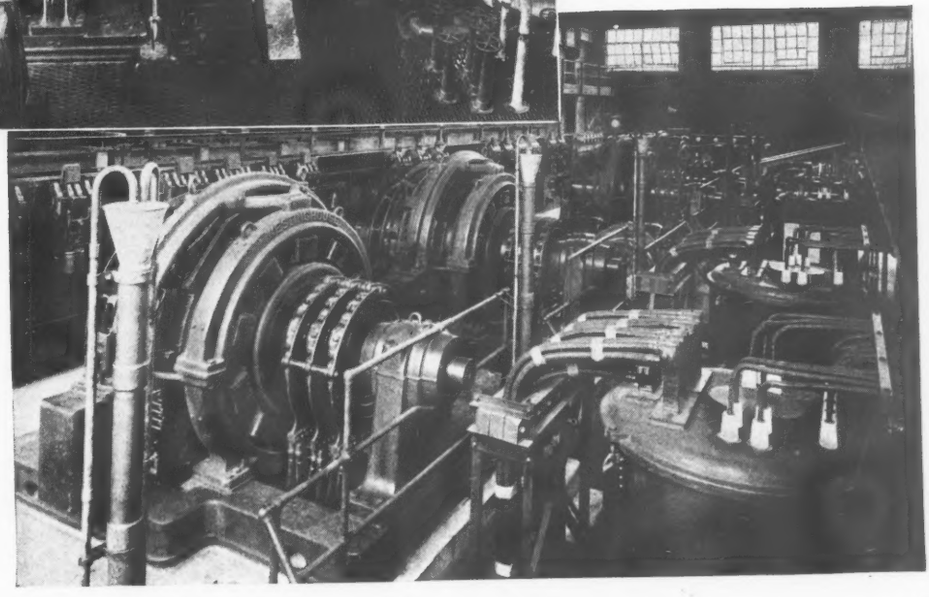


Fig. 3 (Right)—Four-unit rotary-converter substation for supplying direct current from an alternating-current system. Where the source of power is some distance from the electrolytic plant, it is best to generate alternating current and convert to direct current near the process

saving by the higher efficiency machines would more than offset the higher operating and maintenance expense of the synchronous converter installation under these conditions.

If the power factor of the line is poor, motor-generator sets with leading-power-factor motors might

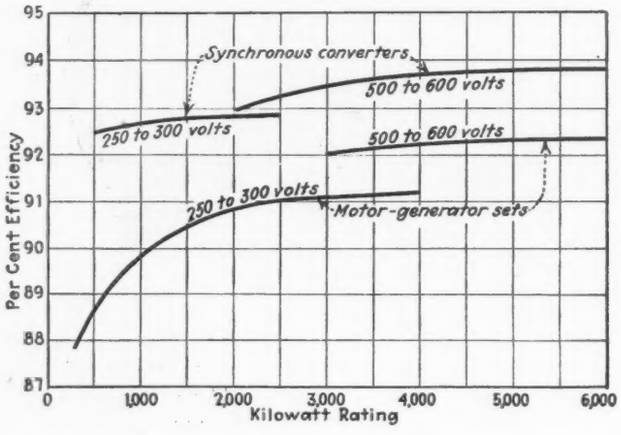


Fig. 4—Efficiency curves of synchronous converters and motor generator sets.

The converter efficiencies include the losses of the converter, transformer, and induction regulator or synchronous booster and 0.3 per cent alternating-current lead loss. The motor-generator-set efficiencies are based on 100 per cent power factor 60-cycle motors. All losses are calculated or measured in accordance with the latest A.I.E.E. rules, and result in overall efficiencies close to the actual.

be more favorably considered. Where power is purchased the possibility of a reduction in the rate for power-factor correction would more than offset the higher efficiency of the converter.

Where these considerations do not enter, the choice of equipment should be made only after a careful analysis of the particular problem. The curves in Figs. 4 to 6 will be of material assistance in the preliminary

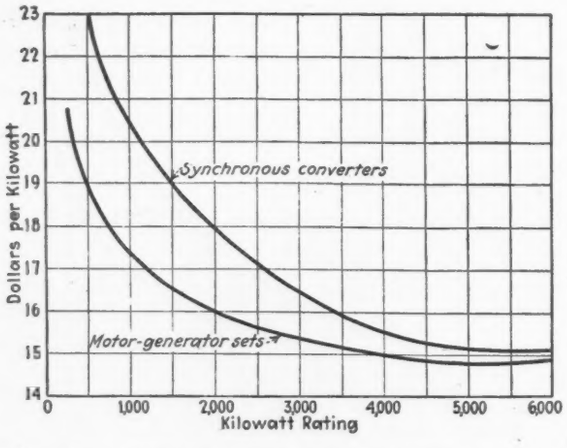


Fig. 5—Prices of synchronous converters and motor-generator sets.

The converter prices include converter, transformer, and induction regulator or synchronous booster for a voltage range of plus and minus five to ten per cent. The converters are rated at 40 deg. C. rise and the transformers at 55 deg. C. rise. The motor-generators-set prices include the complete set, but not transformer prices. These machines are rated at 40 deg. C. rise, with motors for 100 per cent power factor, 3-phase, 60-cycles operation.

stages of a proposition. These curves will enable one to arrive at fairly accurate values for the losses and costs of the motor-generator and synchronous-converter equipment.

No transformer is included with the motor-generator set efficiency and price curves, because for sets, 1,000 kw. and larger, the motor can be built economically for line voltages up to 13,200 volts.

When the line voltage is higher than 13,200 volts or when the motor-generator set is smaller than 1,000 kw., a transformer will have to be used to step the line voltage down to the required motor voltage. Where this condition exists, the motor-generator set curves must be modified to include prices of the transformer and their losses.

Where power generation is to be considered and the power plant must be located at some distance from the

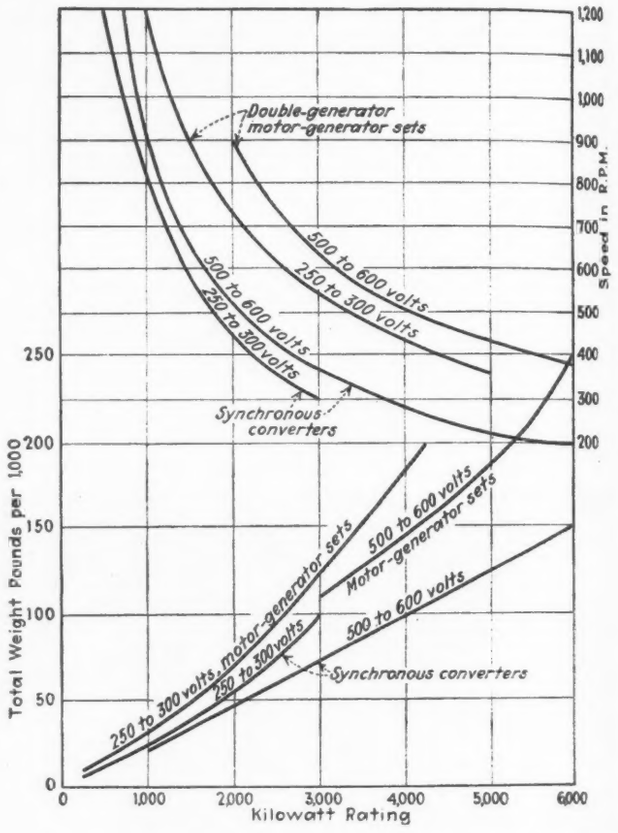


Fig. 6—Kilowatt ratings, speeds and weights of 60-cycle synchronous converters and motor-generator sets

electrolytic plant, alternating-current generation with conversion to direct current at the electrolytic plant is the most practical solution.

When power can be generated close to the electrolytic plant, direct-current generation should be carefully considered. Direct-current generators can be obtained for gearing to steam turbines to form a satisfactory and reliable unit. Probably the largest gear unit in electrolytic service is a single-reduction, single-pinion ten-to-one reduction gear driving two 1,400-kw. 360-r.p.m. direct-current generators. This unit has been in operation a little over two years and has been in service 94 per cent of the time. The 6 per cent outage includes the cleaning of condensers, a general inspection of the unit and routine maintenance.

If exhaust or bled steam can be used for process work, this method of generation has some very attractive features. Careful analysis of this system of power generation will show the following advantages and dis-

advantages when compared with alternating-current generation.

1. Advantages.
   - A. Lower first cost.
   - B. Lower fuel cost.
   - C. Lower labor cost.
   - D. Probably lower maintenance.
2. Disadvantages.
   - A. Lack of flexibility.
   - B. No interconnection with other power systems.
   - C. Probably cannot convert the plant to other than electrolytic use.
   - D. Does not allow a major change in electrolytic circuits.
   - E. Probably low resale value of equipment.

Where steam power or water power is not available and purchased power is expensive but where fuel oil is cheap, direct-current generators direct connected or geared to Diesel engines should be considered. There are no large units of this nature at present in electrolytic service. However, considerable attention is being given to this system of generation.

After a careful study of all the different methods of direct-current production for the electrolytic process the best methods for the particular plant may be selected, and then attention must be given to the proper care of the machines to be used in this severe service. It is important that they be supplied with plenty of clean, cool air, and that a routine of inspection, cleaning and maintenance be established that will keep the machines in first-class condition.

Expert Supervision Necessary in Feed-Water Conditioning

By Captain H. C. Dinger
Officer-in-charge, U. S. Navy Experiment Station Annapolis, Md.

THE important thing in feed-water conditioning is to avoid air, corrosive and scale-forming ingredients in the water. If these are present, remove them as far as possible by distilling or pretreatment. Distilling is the most thorough method, but is also the most expensive in many cases. Where water is essentially hard, decidedly salty, corrosive or contaminated, it is best to use distillation.

If the cost of distilling is considered unjustified and the water is of a nature that will permit of successful pretreatment, then this method is advisable. If water is not greatly contaminated and the cost of the pretreatment plant is not considered justified, conditioning may be accomplished by the properly controlled use of reagents. The advice of a feed-water chemist can often obviate the need for installing expensive apparatus, since under many conditions inexpensive after-treatment is quite satisfactory.

A high-pressure plant requires much more special care and attention than a low-pressure plant. A small quantity of scale is not serious in a low-pressure boiler, but in a high-pressure boiler operated under high ratings the presence of scale is dangerous. Also, the ordinary reagents used do not all function the same under the higher temperature conditions. Lime may be used in low-pressure boilers, but is not suitable for high-pressure. Soda ash also is not satisfactory for very high temperatures. Tri-sodium phosphate is regarded favorably for high-pressure and high temperature. If conditions are reasonably favorable, any boiler can be kept clean under any one of the procedures mentioned; but in each case the precedure must be carried out fully and logically, and frequent periodic tests of feed and boiler water must be made and proper chemical reagents added whenever the tests or analyses indicate that some corrective action is needed.

Many of the special compounds on the market are effective for particular conditions and, if proper chemical control is exercised, work well in particular plants. But no particular reagent is a cure-all. In many cases an inexpensive mixture of ordinary alkalies will give better results than some expensive special compound. Feed treatment based on water analysis and expert examination of boiler operating conditions is the advisable procedure.

How to Select a Compound

The selection of a boiler compound is analogous to the patent medicine situation. The use of certain patent medicines, on the advice of a reputable doctor, is all right, but the indiscriminate use of patent medicines is harmful. In the case of a boiler plant, the feed-water chemist should be called in to prescribe, more or less as a physician does. He can save the plant much trouble and expense if his advice is properly followed. The expense of keeping boilers in efficient condition may be very small, but this depends upon what is put into them.

Boiler-tube failures are coming to notice where unsatisfactory conditions are allowed to prevail. Feeding acid water into boilers is not at all uncommon. The needless accumulation of hard scale is allowed to continue and the operating force treat it as a matter of course. Any boiler plant that requires frequent scaling or that is losing tubes due to corrosion or scale formation, should consult some reliable feed-water chemist to determine whether some feasible remedy may not be applied. The remedy is often very inexpensive.

Using compounds by rule-of-thumb—so many pounds for so much raw feed or steam evaporated—is neither scientific nor safe. It may be better than nothing. If feed conditions remain the same and the correct procedure happens to be hit upon, it will be all right; but conditions are usually not uniform, and the only sure way to know what the actual conditions are is to make periodic test and analysis of the boiler water. The tests to be made are comparatively simple and, under the occasional direction or supervision of a chemist, can be made by the boiler-room personnel. One feed-water expert can check up on the feed conditioning of many boilers and by watching the varying conditions can vary the feed conditioning so that the boilers are kept continuously clean and free from corrosion.

No particular feed conditioning apparatus or set procedure is really automatic in its operation. It must be checked and supervised in order that the desired results be secured. The quantities of various reagents to be added may have to be varied considerably from time to time, and the blow-down also will have to be varied according to the concentration and the amount of solids or sludge that is thrown down.

No matter what feed-conditioning apparatus is in service, it should be controlled by some expert with the necessary chemical knowledge of chemical feed-water reactions.

Load Dump Tests Made on Colfax Turbines

The Turbine Governors Were Improved so as to Limit Overspeeding to 9.1 per Cent When Full Load Is Dropped

By T. E. Purcell
General Superintendent of Power Stations
Duquesne Light Company

Because of the severe operating conditions brought about by frequent summer electrical storms, the Colfax Power Station of the Duquesne Light Company has been the scene of unusual development in steam-turbine governor practice. All power from Colfax is fed over 73-kv. transmission lines. On many occasions practically the entire station load has been dropped instantaneously when lightning opened transmission line breakers. At such times, one or more of the main unit turbines would overspeed, thus tripping its throttle and causing delay in picking up the load. The governor development work was undertaken in an attempt to adjust the operating governors so they would hold the maximum speed below that at which the overspeed governors are set, namely 11 per cent above normal. The governing gear on all turbines was of the oil relay type, the relays being controlled by flyball governors.

The No. 1 and No. 2 units at Colfax are of 60,000-kw. capacity. Each unit consists of three separate turbine elements; a high-pressure turbine driving an independent generator at 1,800 r.p.m., which exhausts to two low-pressure single-cylinder double-flow elements that operate at 1,200 r.p.m. The governing mechanism is controlled by the main governors on the high-pressure turbines for the normal operating conditions. Fig. 1 is a cross-sectional view of the main high-pressure governor assembly. One of the important design features is the rotating sleeve, which effectively eliminates the friction of rest found in governor constructions where there is sliding of the sleeves without rotation relative to the guides. The governor is driven by worm gears from the main turbine spindle.

The steam supply to these units enters the governing valve through two 18-in. steam mains. All of the steam passes through the main primary valve, which is of the usual double-disk balanced type, with 21-in. diameter seats.

For loads exceeding 45,000 kw. a secondary valve bypasses the first group of high-pressure reaction blades up to the rated load of 60,000 kw. A tertiary valve next opens to secure a maximum load of about 72,000 kw.

As all the steam must pass through the main primary valve, it is obvious that this valve must be closed quickly, if the speed jump is to be kept down to a minimum. In the original design, the standard governor, shown in Fig. 1, was arranged to operate the main primary valve through a $1\frac{3}{4}$-in. diameter relay and an 11-in. operating cylinder. In addition to the duty imposed on the governor of overcoming the frictional and hydraulic resistances of the $1\frac{3}{4}$-in. main primary relay, the governor was also forced to move the relay that operated the secondary and tertiary valves. The combined resistances were sufficient to slow the mechanism down to a considerable degree when the governor was called upon to drop the maximum load in one step.

The original 60,000-kw. governor arrangement included the governor vibrator, which involved a power driven cam that was arranged to move one of the fulcrum points of the relay linkage an amount sufficient to cause a continuous periodic motion of the main valve linkage at 266 cycles per minute. This was considered necessary in order to prevent sticking.

The vibrating mechanism might still be employed were it not for a dashpot that was necessary at the governor end of the relay linkage to prevent an undue oscillation of the governor sleeve and weights. The dashpot obviously slows down the governor linkage to a considerable degree against rapid motion.

After a thorough study of the governor action, the 60,000-kw. governor mechanisms were redesigned and rebuilt, to secure a quick response to rapid changes in speed. A substantial improvement in the operating characteristics of these governors has resulted from this work.

The first change involved the altering of the mechanisms from a single to a double relay arrangement. In the new scheme, the main governor is connected to operate a $1\frac{1}{4}$-in. diameter relay, in which the frictional and hydraulic resistances are small. This relay valve admits high-pressure oil to a 4-in. diameter operating cylinder that is connected by a lever to a longitudinal rock shaft. The active stroke of the governor sleeve of $2\frac{1}{4}$ in. causes the rock shaft to move through an angle of approximately 45 deg. The introduction of this double relay arrangement for the rock shaft control permits the governor to follow the turbine speed with very little lag,

thus eliminating one of the sources of overspeeding found in the original single relay governor arrangement.

The governor rock shaft is connected at one end to a 4-in. relay that operates the main primary governing valve. The other end of the rock shaft is connected to the relay that controls the secondary and tertiary valves.

The governor vibrating mechanism and dashpot features were eliminated from the design.

The next change of importance was the substitution of a 4-in. diameter main relay on the primary valve. A special sleeve construction is employed to reduce to a minimum the hydraulic resistances, which becomes of great importance in governor mechanisms where quick response is essential. The ports and oil passages are everywhere made to permit a rapid motion when the main valve is closing.

Fig. 2 shows in section the final design of primary operating mechanism with the 4-in. primary relay and the 10-in. operating cylinder. The motion of the main primary governor valve is so rapid, that a dashpot is necessary to reduce the rate of motion of the moving parts just before the main governing valve seats come in contact.

To augment the capacity of the main oil pump a hydraulic accumulator of special construction was installed, the design being such that the accumulator acts not only as a source of hydraulic power when a rapid motion of the valves is necessary, but also to take the place of the usual spring-loaded relief valve, by means of which the supply of high-pressure governor oil is reduced to the bearing line pressure. This accumulator is shown in Fig. 3. When the governor mechanism is in a position of equilibrium the accumulator piston rises until it uncovers the overflow ports near the top of the stroke that discharge to the bearing supply system, thus acting in the capacity of a weight-loaded reducing valve. When the governor mechanism is in rapid motion, the weight descends and gives up a portion of its stored energy to augment the capacity of the main oil pumps, thus securing a still more rapid motion of the governing valve. Unless special provisions are made, the bearing system would be temporarily robbed of its oil supply during the time the accumulator weight is being raised by the main oil pumps after a rapid closing of the valves. The bearing oil supply is maintained by ports arranged so that oil at bearing pressure is stored on top of the accumulator piston when the weight is descending. This stored oil supplies the bearing system while the high-pressure oil pump is again storing high-pressure oil by raising the accumulator weight.

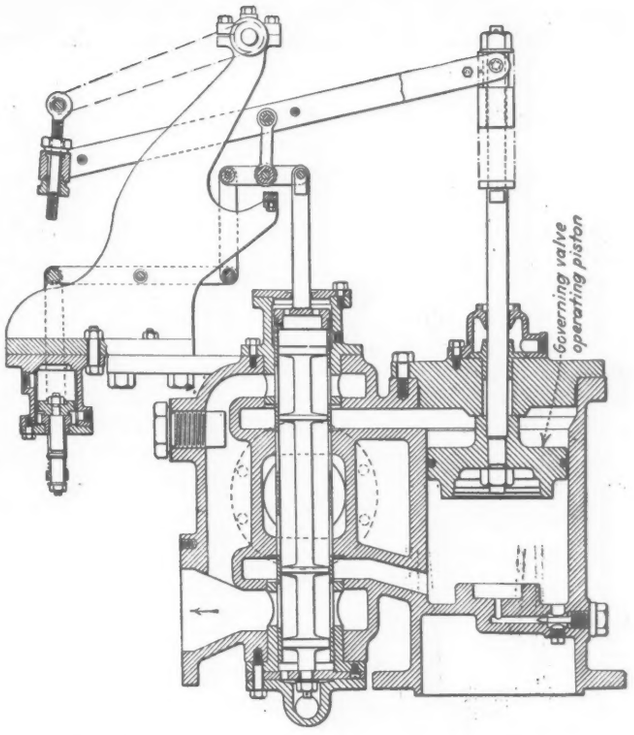


Fig. 2—Final design of double-relay governor operating mechanism

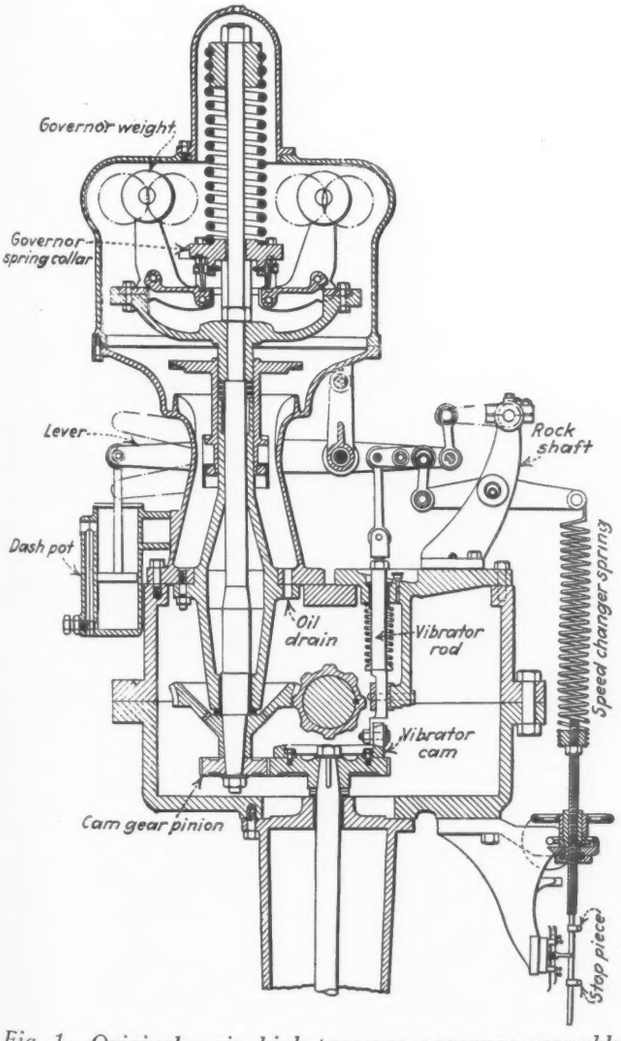


Fig. 1—Original main high-pressure governor assembly

While the above changes were made to the governor mechanisms, the oil pressure in the governing system was increased from 60 to 75 lb. per sq.in.

After the governor mechanisms had been modified, it was found that the primary valve moved through its full travel in approximately one-tenth of a second when the 1¼-in. governor relay was moved by hand. To secure this extremely rapid motion it was necessary to make the pipes to and from the main primary relay 6-in. in diameter.

In order to determine the effect of these various changes, on the governor characteristics, load dumping tests were conducted during which the maximum load that could be carried on the machine with all valves wide

open was released in one step. Observations were made of the maximum speed attained by the unit and the time taken for the governor and main valve to react.

Equipment Used During Load-Dumping Tests

For these tests, equipment was developed for the determination of the speed-time characteristics of the governor. Many types of instruments were considered and tried out, the final arrangement included a small magneto direct-connected to the end of the main generator spindle without reduction gears. This magneto, built by the Weston Instrument Company, was found to have excellent characteristics when enclosed in a box in which heater lamps controlled by thermostats were used to maintain a constant temperature. The magneto has a practically straight voltage-speed characteristic of six volts per 1,000 r.p.m. In the recording tachometer, shown in Fig. 5, a millivoltmeter element is employed by means of which the magneto voltage can be directly observed on the graduated scale. A bucking battery opposes the voltage of the magneto so that the millivoltmeter indicates only the difference in voltages. With this arrangement it is possible to use the low-voltage winding of the millivoltmeter, and thus secure a relatively large movement of the needle for a small change in the speed of the turbine.

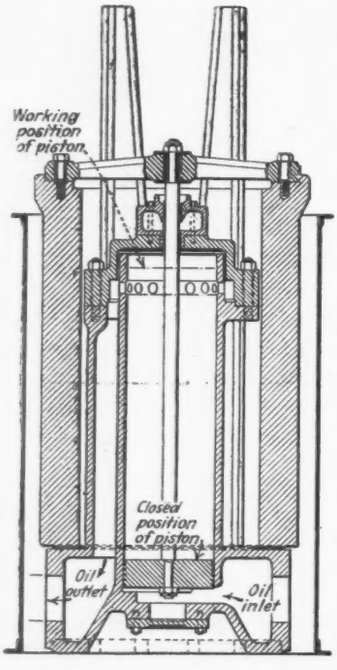


Fig. 3—Cross-section of oil accumulator

The millivoltmeter needle is equipped with an insulated extension piece that carries a small platinum wire at right angles to the needle. Two curved insulated platinum rods, one above and one below the platinum wire at the end of the needle, are attached to the frame of the instrument and connected to the terminals of a small spark coil. When the circuit is established, the spark jumps from the upper platinum rod to the small extension pieces on the end of the needle and from there to the curved platinum rod below.

A paper chart, controlled by a small motor, is moved through the lower air gap between the conductor on the end of the needle and the lower conductor attached to the frame, so that when the spark jumps through the air gap, it punctures the paper.

The speed of the paper is adjusted at from two to three inches per second. The line traced by the spark punctures can easily be seen by placing the chart over a piece of illuminated ground glass and tracing the record with a pencil. The electromagnetic timing device is actuated by a seconds pendulum.

Other instruments were constructed and used to record the variation of oil pressure in various parts of the governing system, the variation of steam pressure, the position of the main valves, accumulator weights, and relays during the tests. Instruments for recording these various events were equipped with time markers actuated from the same seconds pendulum. By operating a special switch in the seconds pendulum circuit, marks are made to establish a common time datum on all the records.

Fig. 4 shows the results of the load dumping tests on one of the 60,000-kw. turbines. It will be seen that the

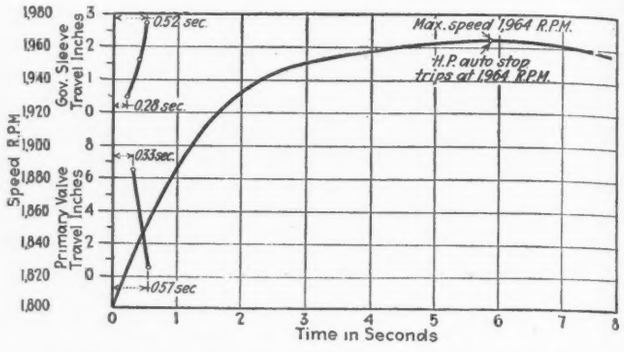


Fig. 4—Performance of 60,000-kw. unit in load-dumping test

maximum speed reaches 9.1 per cent above normal speed. In this test, the overspeed stop had not been given the final setting.

This is somewhat below the tripping speed of the overspeed stops, which are set to operate at 11 per cent above normal frequency on all Colfax turbines. The radical changes in design and the extremely rapid valve motion secured were necessary to offset the effect of the large volumes of steam trapped between the primary inlet valve and the turbine blades. After the main primary valve is closed, this steam continues to give up energy to the turbine blades until the no-load pressure distribution is reached. While the result is not so good as can be obtained on single-cylinder machines, yet it

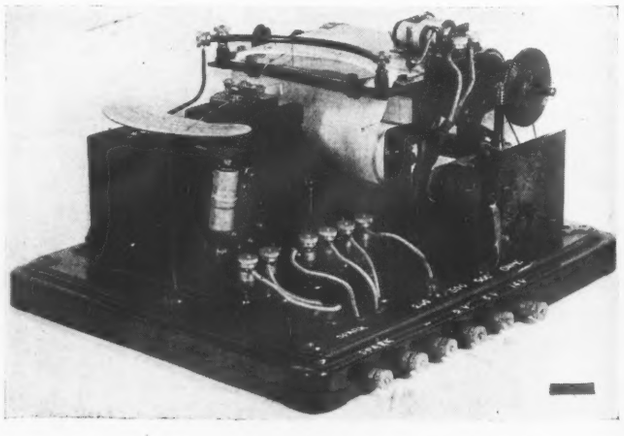


Fig. 5—Recording tachometer used in the governor tests

has been found that the service rendered by these governors in over two years of operation has been satisfactory in every way.

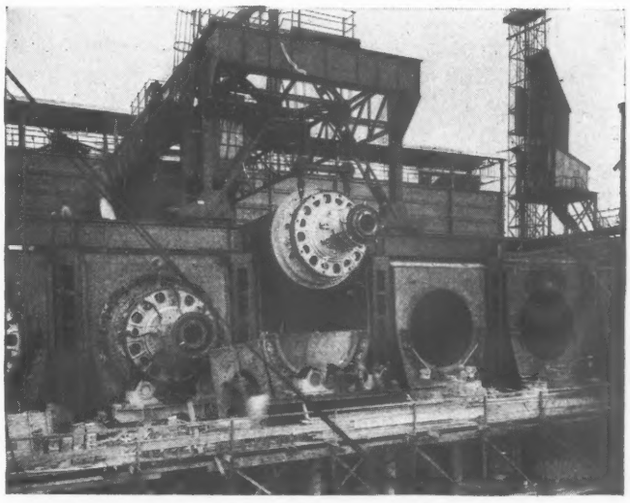
An article in the next issue will describe the governing system of the Colfax 40,000-kw. unit which is equipped with a centrifugal oil impeller type governor.

LOW TEMPERATURE CARBONIZATION

Developed Commercially

First Large-scale American Plant Operates at New Brunswick

BY G. L. MONTGOMERY
Associate Editor, Power

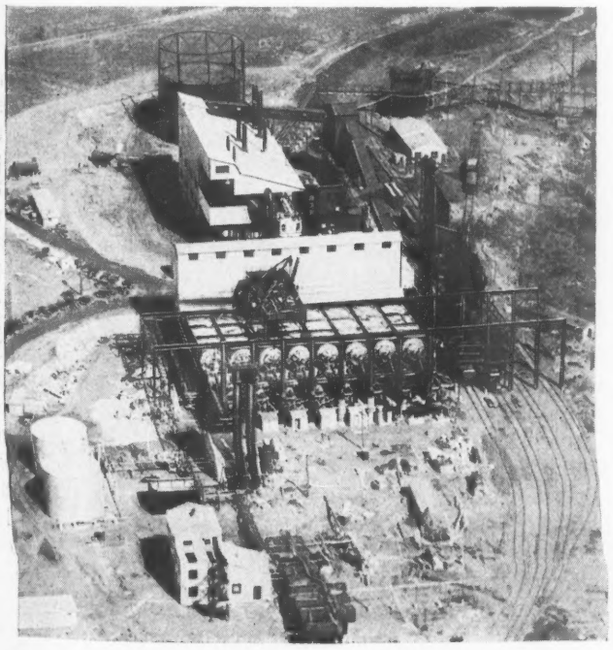


Placing a retort in its refractory setting, during construction of the New Brunswick plant

A YEAR or more ago, announcement was made, in newspapers and the business press, that a large low-temperature carbonization plant was to be built in New Brunswick, N. J. This plant, of 250,000 tons yearly carbonizing capacity has been designed and constructed by the International Coal Carbonization Company, a subsidiary of the International Combustion Engineering Corporation. It is the largest plant of its kind in the world, and the only plant of commercial size now operating in the United States.

This installation has not been entirely completed and is only partly in operation at the present time; but already a second plant has been commenced which will serve the fuel needs of the Lukens Steel Company, at Coatesville, Pa. Apparently the low temperature treatment of coal has at last reached the stage of commercial development, a fact important to power engineers because of the possibilities held forth for cheapening the power generating process.

Airplane view of America's first large low-temperature coal carbonization plant as it neared completion



The New Brunswick plant will be operated by the New Jersey Coal & Tar Company, another subsidiary of the International Combustion Engineering Corporation. It employs the K.S.G. process, which it controls. This process produces from bituminous slack, in a single operation, smokeless fuel, gas, tar and light oil.

The smokeless fuel, which burns with a short blue flame, is marketed under the trade-marked name "Disco." It is porous in structure, igniting more readily than coke or anthracite, and responding quickly to draft changes. About 1,500 lb. of this fuel is obtained from each ton of coal carbonized. Of this, about 1,200 lb. is of salable size, while the remaining 300 lb. of fines is sufficient to supply producer gas for heating the carbonizing retorts and to fire boilers that produce steam for all plant needs, both process and power.

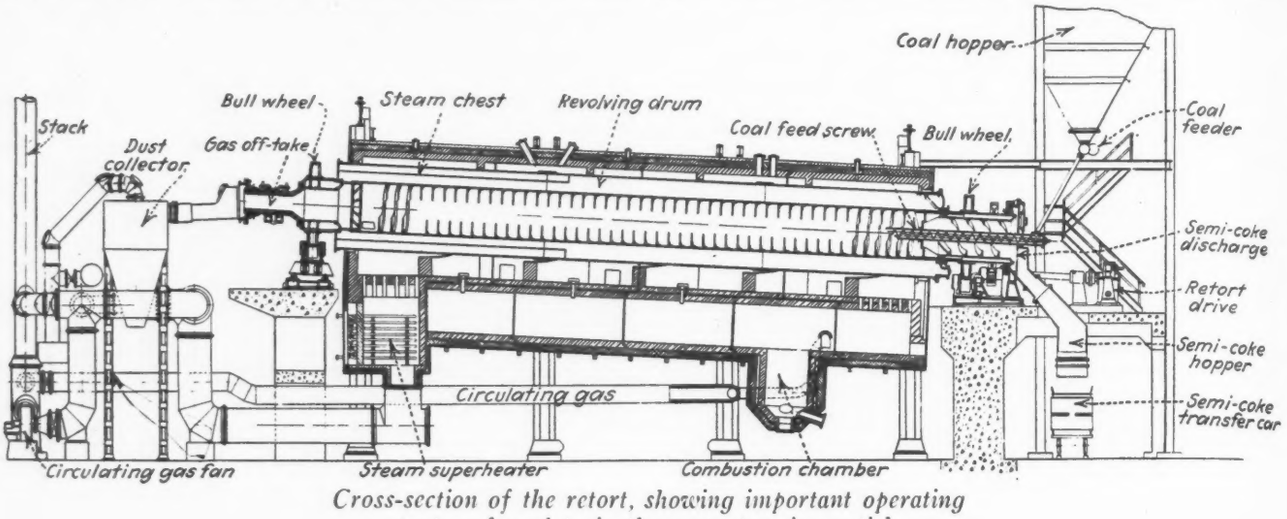
Burned under the boilers on chain-grate stokers, this finely divided "Disco" gives satisfactory results. No figures are available as yet as to the heat release per square foot of grate area or the pounds of fuel burned per square foot, but these figures promise to be well above averages for coal.

Other products of the plant are, per ton of coal carbonized: 3,500 cu. ft. of 900 B.t.u. gas, 25 gallons of tar, and about 2.5 gallons of light oil (a satisfactory anti-knock motor fuel).

The New Brunswick plant has a contract with the Public Service Gas & Electric Corporation of New Jersey for the delivery of a minimum of 3,000,000 cu.ft. per day of gas having a calorific value of 535 B.t.u. per cu.ft. Since the retorts are externally heated by producer gas, the entire production of rich gas is available for sale. This is mixed with 300 B.t.u. blue gas, made from bituminous coal, so that the mixed 535 B.t.u. gas amounts to about 8,000 cu.ft. per ton of coal carbonized.

The tar and light oil are sold to the International Com-

bustion Tar & Chemical Corporation, another subsidiary of the International Combustion Engineering Corporation, at a figure in excess of the current market for high-temperature tar. Upon distillation the tar yields a wood-preserving creosote oil. This tar, moreover, has a high content of phenols. As compared with high-temperature carbonization, there is recovered from a ton of coal more



Cross-section of the retort, showing important operating parts referred to in the accompanying article

than five times the quantity of phenols suitable for manufacture into synthetic resins. There is now developing for this remarkable material a tonnage market involving the production of furniture, doors, wainscoting and interior trim. In addition to the light oil scrubbed from the gas about five gallons more can be distilled from the tar.

The plant contains eight retorts. Each retort has a rated capacity of 80 tons of coal per day, but it is believed that this rating is conservative, as the Essen plant at times has reached a throughput of 100 tons.

A retort is shown in section in the accompanying illustration. It consists of two concentric drums, externally heated, inclined slightly from the horizontal, and rotated on the bullrings at each end at three quarters of a revolution per minute. The outer drum is 72 ft. long, with a 10 ft. diameter, while the inner drum is 85 ft. long with a 5½ ft. diameter.

Raw coal is fed continuously from a storage bin into the retort by a screw conveyor. Helical flanges in the inner drum carry it to the upper end, where it spills through open ports into the outer drum. It then moves to the lower end of the retort, where it is picked up by a series of scoops, dropped to a receiving plate and carried by the reverse helical flanges to the discharge gate. The fuel is in the retort about two hours. The gas produced during this time escapes through the drum head and the off-take pipe at the upper end of the retort.

The principle involved in the double drum arrangement is that of reducing to a minimum the time that the fuel is in the plastic state. The coal during its passage through the inner drum is dried and heated to a point below its softening temperature. It is then plunged into the upper end of the outer retort, where the highest temperatures are maintained. Each individual coal particle is thus almost immediately "case-hardened," so to speak, with a layer of non-sticky semi-coke, so that its agglomerating properties are correspondingly reduced. Ample provision has been made to recuperate the heat in the stack gases.

The means taken to prevent carbon deposits on the walls is the introduction of steam through a series of steam chests. There are eight of these chests extending along the inner wall of the outer drum for the upper third of its length, but by means of an automatic valve the steam is admitted only through those that are actually under the fuel bed. The direction of the steam is tangential, so that a screen of vapor is continuously interposed between the fuel and the retort walls. As a final precaution, a number of chains are stretched longitudinally in the upper end of the outer retort, so that any adhering carbon is scraped off. This method of dealing with a coking coal has been so successful that the K-S-G retort near Essen has never had to be taken out of service for cleaning.

The problem in heating the retort is to obtain variable temperature control and a high thermal efficiency. Moreover, since the retort is made of steel, it is necessary to maintain a neutral atmosphere to prevent oxidation. As mentioned above, the cheapest possible gaseous fuel is used, which is hot producer gas made from the semi-coke fines. This is generated in a central producer gas plant, but each retort has an independent heating system. The gas is burned in a combustion chamber, where gas and air are admitted through two proportioning burners in exact combining ratio. Consequently a temperature of about 2,500 deg. F. is obtained at this point, which is considerably higher than that desired in the retort flues. Rather than use excess air for cooling, with resultant loss of thermal efficiency and oxidation of the retort, the stack gas recirculation system is employed.

In this system a circulating fan takes a portion of the blue gases from the base of the stack, mixes it with some of the hot gases from the combustion chamber and forces it into the first pass at the lower end of the retort setting, where a temperature of about 1,200 deg. F. is maintained. The flow of this mixed heating-gas is baffled to make it take a helical course around the retort. The heat abstracted from it by the carbonizing coal is replaced by introducing hot combustion chamber gas into each pass through ports connecting with a central flue running longitudinally under the retort. The dampers in these ports are so arranged that increasingly higher temperatures are maintained in each pass, reaching 1,350 deg. F. in the uppermost pass surrounding that part of the retort where the coal falls from the inner to the outer drum.

The hot gases leaving the retort setting pass directly into the steam superheater, thence through the jacket

around the dust catcher, (which is heated to prevent condensation of tar), and into the stack. The superheater is a nest of alloy steel tubes. From 100 to 200 lb. of exhaust steam per ton of coal are raised by the superheater to a temperature of 900 deg. F. Since this steam leaves the retort at almost the same temperature, it does not contribute to the heat of carbonization. Its function is both to prevent carbon formation on the retort walls and to prevent excessive cracking of the tar vapor. The gross heat of carbonization is about 800 B.t.u. per lb.

The coal gas, tar vapor and steam leaving the retort pass first through a dust-catcher. The amount of dust collected is less than 0.1 per cent of the coal processed and no difficulty is experienced with emulsions, dehydration being satisfactorily accomplished by simple settling. The pressure in the retorts is maintained constant by an automatic control system, acting through dampers in each of the coal-gas off-take lines and the governor of the exhauster.

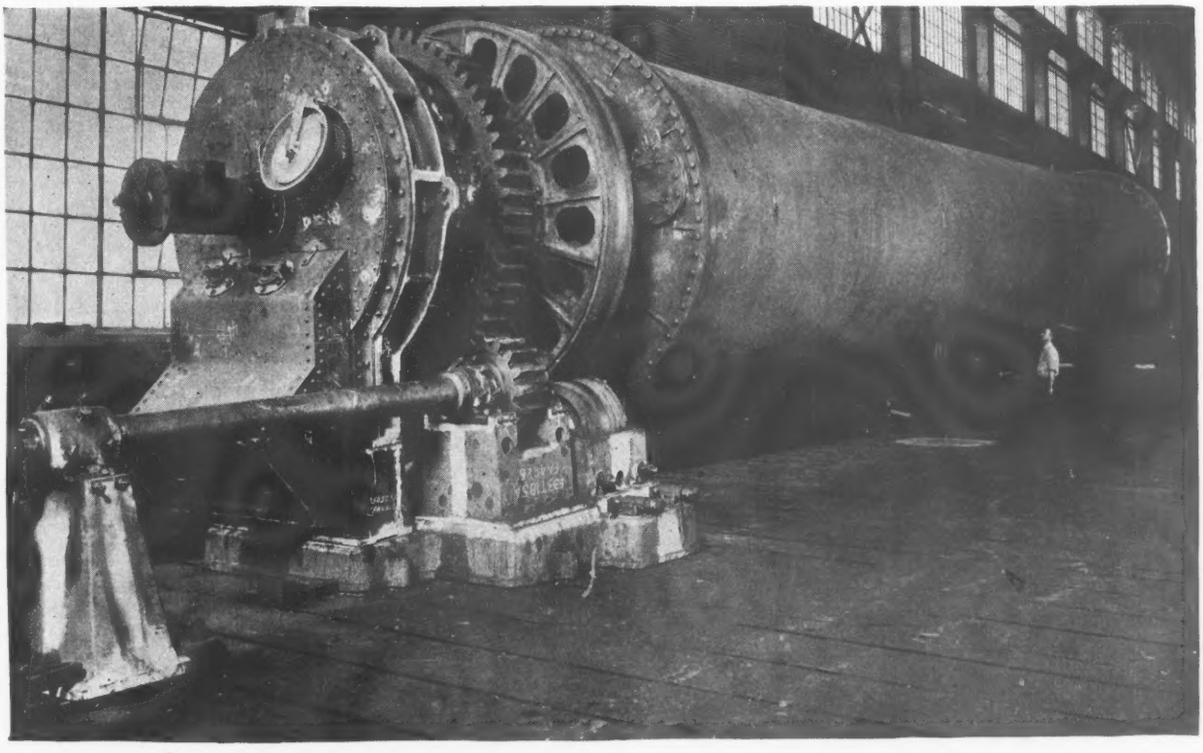
All units are built in duplicate, so that one spare is always available. There are two producers, equipped with rotating bottoms for automatic ash elimination and water-jacketed for waste-heat steam generation. The water-gas plant comprises two 11-ft. generators, hand-clinkered, but automatically charged, with waste-heat boilers for the stack gases. While this plant will make only blue gas in regular operation, each set is provided with a carburetor and superheater. Thus, in the event of any interruption in the operations of the retort house, the blue gas can be enriched by oil gas instead of coal gas.

The steam plant consists of two 5,000-sq.ft. boilers, operating at 200 lb. and equipped with stokers to burn semi-coke breeze. Since both the producers and the blue-gas generators are nearly self-supporting, so far as steam requirements are concerned, the main function of the boiler plant is to supply steam for motive power. Steam is used to drive the coal-gas exhausters, the engines rotating the retorts, and the various tar and oil pumps. Compared with electric operation, not only is greater flexibility of speed thus made possible and greater assurance obtained of continuity of operation, but also exhaust steam is made available in quantity nearly sufficient to meet the requirements of the carbonizing process.

The semi-coke from the hot cars is raised and discharged into the dry quencher, which is simply a container through which cold inert gases are circulated. No attempt is made at New Brunswick to generate waste-heat steam, as in the usual application of dry-quenching to high-temperature coke plants. The operation justifies itself merely on the ground of thorough and uniform cooling of the semi-coke to less than 200 deg. F., which is well under its ignition temperature, without having to resort to drastic water quenching and the resultant increase in the percentage of unsalable fine sizes.

An inclined conveyor carries the quenched semi-coke to the coke-screening house. Here it is screened into the usual domestic sizes, $\frac{3}{4}$ inch being the smallest size to be offered for sale. Hoppers for three marketable grades are installed, with provision for discharging either into railroad cars or motor trucks. Of the semi-coke sizes smaller than $\frac{3}{4}$ in., the $\frac{1}{4}$ to $\frac{3}{4}$ in. is used for producer fuel and that under $\frac{1}{4}$-in. for boiler fuel. It has been the experience at Essen that 80 per cent of the run-of-retort is recovered in lumps larger than $\frac{3}{4}$ inch.

The coal gas passes through a primary cooler of the indirect type to the exhauster and thence through a scrubbing tower for removal of the light oil. The blue gas purification train consists of a primary cooler, a relief holder, and a secondary cooler. The coal gas and blue gas are then combined in an automatic proportioning valve and pass through sulphur purification boxes to the storage holder of the New Jersey Public Service Electric & Gas Company on an adjacent property.



One of the eight retorts, before installation

Right Out of the Plant

Paralleling a Turbine-Generator with a Motor-Generator

ANSWERING W.J.D's. question, page 325, Feb. 19 number, I can see no serious difficulty if the 125-kva. motor-generator is paralleled with the 100-kva. turbine-generator. It may be necessary to put additional steps in the motor-field rheostat near the synchronizing speed, to obtain as nearly true synchronous speed of the incoming machine as practical. When operating the two units in parallel, their speed regulation should be approximately the same, if the load is to be divided proportionately.

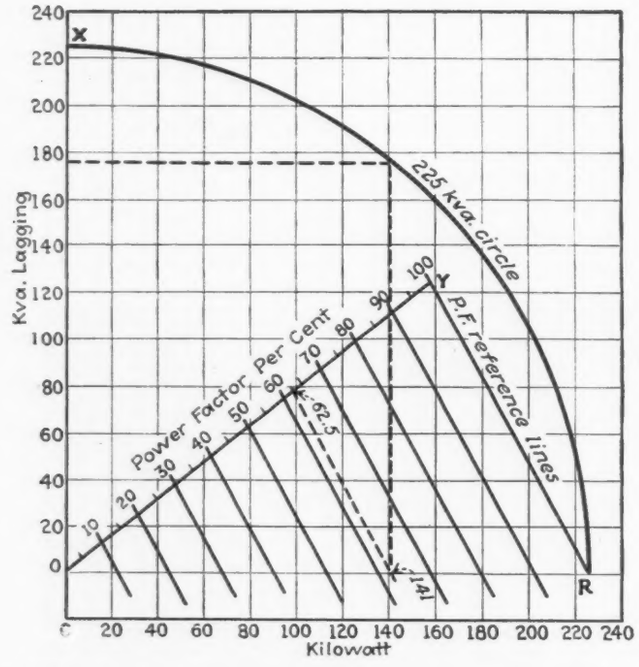


Chart for solving alternating-current generator-load problems

When the machines are in parallel, the speed of one cannot be increased above that of the other. Weakening the field of the motor driving the generator will tend to increase its speed above that of the turbine, and the former set will pick up load, the speed of both machines increasing slightly.

To operate the turbine generator as a condenser, the main throttle valve should be by-passed with a ½-in. pipe, having two valves. One of these valves is to be used as a stop valve and the other as a throttling valve. Three or more small grooves should be filed in the seat of the throttling valve. With both units carrying load, the proper method to put the turbine unit on condenser operation would be to open both bypass valves, then gradually close the main throttle valve of the turbine. After the main throttle valve is closed, gradually close the throttling valve in the by-pass until the outgoing wattmeter reads 0. Meanwhile, watch the alternating-current ammeter and adjust the excitation so as not to exceed full-load amperes on the generator.

The slots in the throttling valve are to guard against shutting off all steam from the turbine when its generator is running as a condenser, as a small amount of steam is required under such conditions to keep the blades cool.

Assuming ten kilowatts required to run the turbine-generator as a motor, it can be used as a condenser obtaning about 99.5 leading component giving unity power factor on the motor-generator set when both machines are carrying a total load of 160 kva. at 78 per cent lagging power factor. With less than 160-kva. total load at 78 per cent power factor, or the same load with a higher power factor, the motor generator can be given a leading power factor.

Load and Power Factor Problems

The figure shows how to determine graphically the kilowatt load and power factor for any given capacity generator or transformer. Select a convenient scale for the capacity of the generators in this case 225 kva., the combined capacity of the two units under discussion. Lay off the total capacity in kilowatts, to the selected scale, on the base line. With *O* as a center, draw a quadrant equal to the capacity of the units at 100 per cent power factor. Using a convenient scale and angle, draw line *OY*, having 100 divisions. Draw the line *YR*. Then, draw lines through nine divisions on *OY*, all parallel to *YR*. These lines are power-factor lines. The base line shows kilowatts and the vertical scale gives lagging kilovolt-amperes.

For the given problem of the two units rated at 100 and 125 kva. respectively, the chart shows that when both are operating as generators at full rated kva.. they will supply about 141-kw. load at 62.5 per cent power factor. To obtain the solution to the problem on the chart, from the 62.5 per cent point on the power-factor line *OY*, lay a straight edge parallel to the power factor reference line *YR*, and read 141 kw. where the straight edge intersects the base line *OR*. From this point (141) on the base line run vertically to the circle and from this intersection follow horizontally to the left as indicated by the dotted lines; read the lagging kva. on the vertical scale. The lagging kva. is about 176. This condition exists with both machines operating at the same power factor.

To find the power factor and the lagging kva. for full-load and any given kilowatt load, assume a load of 185 kw. Through 185 on the base line lay a straight edge parallel to the power-factor line *RY* and read the power factor, about 82 per cent, where the straight edge cuts the power factor line *OY*. From 185 on the base line follow vertically to the circle, then horizontally to the left and read about 128 lagging kva. on the vertical scale. This shows that at 82 per cent power factor the two machines can supply a 185-kw. load. The total kva. is 225 as before and the lagging component is 128 kva. Any other combinations of load may be checked by the foregoing method.

M. H. Curley.

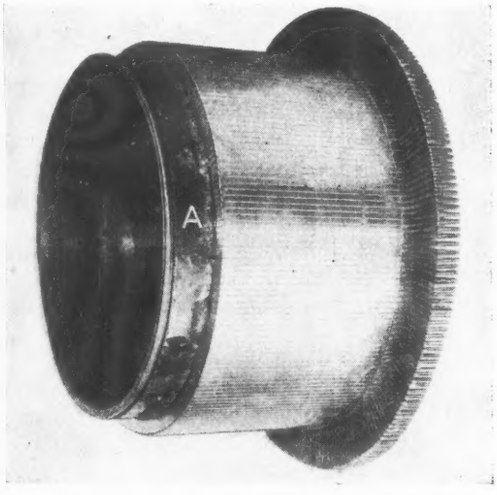
Bay Shore, N. Y.

Commutator Trouble Reduced at Front Vee-Ring

A MOTOR or generator may develop trouble at the front end of the commutator, due to oil and dirt collecting, and causing a short circuit between bars or grounds. The front mica vee-ring on all types of motors or generators should be kept clean. A hard smooth surface is essential for ease of cleaning and permanent cleanliness, which can be provided by two methods.

The first method is to band the mica, shown at *A* in the figure, and applies to armatures that can be easily rotated. Italian twine is used for the band because of its high mechanical strength, soft texture, slow ageing and absorbing qualities. When this twine is applied according to following directions it results in a band that is easily kept clean, and one that reduces trouble to a minimum.

In applying this band, all old insulation should be



A twine or tape band should be applied over the mica vee-ring A

removed down to the mica, and the mica ring sandpapered clean. After this is done, brush on a coat of orange shellac and apply the twine band while the shellac is wet. The band should be tight, the turns close together and the end of the band looped under at least six turns. On top of this band apply four coats of shellac, using a hot iron to iron in each coat. This latter sets and fills the band.

The next operation is to sandpaper the band to obtain a smooth surface, after which apply four coats of red oxide enamel at a specific gravity of 0.835 and allow each coat to air dry. If the second or third coats appear lumpy, they should be sandpapered. The time spent on this type of band is repaid by the resulting freedom from trouble.

The second method is used where it is impractical to apply a string band, or on high-speed machines. This method uses surgical braid or tape 0.020-in. thick and 1-in. or 1¼-in. wide. The mica ring is first cleaned. Then the tape is saturated in a clear or amber-colored baking varnish at a specific gravity of 0.835 and applied while wet. Surgical tape is used because of its high mechanical strength, flexibility, and weave that precludes unravelling. Soaking in varnish and applying while wet, fills the tape and results in a seal that extends clear through the fabrics.

The free end of the tape should be doubled over and sewed to the turns below it. For high-speed machines, the edges of each turn of tape should be sewed all around the ring. This prevents the edges from rising during operation. This band is also finished with four coats of red oxide enamel, sandpapering between coats when necessary, to insure a smooth final coat. The finished bands are red in color and can be sprayed with a high-grade black air-drying varnish, if desired, but the red finish can be wiped clean to better advantage.

A. C. Roe,
Westinghouse Electric & Manufacturing Co.
East Pittsburgh, Pa.

Over-Fire Air With Stokers

THE editorial suggestion in your March 19 number that modifications in stoker design and operation may be desirable in order to realize the advantages of admitting air directly over the fire is well made.

Experiments carried out by the U.S. Bureau of Mines several years ago, under the direction of Dr. O. P. Hood, showed conclusively that with a perfect fuel bed, that it, one free from channels and fissures, the composition of the issuing gases is independent of the amount of air supplied through the bed, or in other words, the fuel bed changes the solid fuel to producer gas, so that secondary air must be added in order to complete combustion. Blowing more air through the fuel bed only produces more gas, that is, one pound of coal is gasified for each seven pounds of air passed through the bed, the oxygen of the primary air being consumed within a distance of about six inches from the grate.

Similar facts were discovered at about the same time in Germany by William Nusselt who explored with a sampling tube, just over the surface of the incandescent fuel.

So-called two-stage combustion has been studied by a number of investigators, including C. E. Stromeyer, of England. He proposed to absorb some of the heat from the gas-producing reaction, either by means of radiation or by passing the gases over convection heat-absorbing surfaces, before introducing the secondary air. With modern water-cooled furnace walls, the primary convection surface is probably unnecessary.

The Kestner two-stage combustion, which has been tried out in France, combines complete combustion with moderate furnace temperature in a similar manner. It includes a semi-producer type of continuous furnace designed to regulate the coal and air supply, primary boiler surface to cool the gases to the lowest temperature (about 1,100 deg. F.) which will permit of re-ignition, a device for mixing secondary air with the gases thus cooled, preferably baffles, and a secondary boiler element wherein the heat from the completed combustion is absorbed. In describing an installation of this type, Henry Dieterlen states that the air can be reduced until only 3 per cent, or even 1 per cent, oxygen remains at the flue damper, although reducing it sufficiently to give zero oxygen may result in smoke. The best practice, he states, is about 19 per cent CO_2, no CO and ½ per cent oxygen in the chimney gases. E. C. Mills, in England, placed a gas producer with a revolving conical step grate in front of a Lancashire boiler. The combination is reported to have produced 10 to 11 lb. of steam per

pound of coal, with 18 per cent saving over ordinary methods of firing, but gas analyses are not given.

A similar suggestion was advanced by William B. Chapman, at the recent Cleveland meeting of the A.S.M.E. Fuel Division, who expressed the belief that a modified form of underfeed producer suitable for boilers would be brought out before long.

The introduction of secondary air above the fuel bed has long been practiced in the so-called "half gas" methods of firing used in Germany and elsewhere for burning brown coal, lignite and peat, usually upon inclined grates fed by hand or from a hopper.

The supplying of a large part, up to one half, of the total air above the fuel bed, greatly relieves the tendency of the blast to carry up particles of ash and fuel into suspension in the furnace, and thereby reduces the tendency to slagging on the boiler tubes and to carrying out of ash particles and cinders through the chimney, advantages which, added to the ability to carry a higher CO_2 percentage, should make this system of combustion an able competitor of powdered fuel.

Methods and means are commercially available for holding the primary and secondary air supplies in strict proportion to one another and to the steam demand or furnace heat requirements. GEO. H. GIBSON.

New York City.

Why the Compressor Belt Flapped

COMMENT on the article "Why the Air-Compressor Belt Flapped," in the March 19 issue focusses attention on this installation as one of the most severe of drives. Here are two single-cylinder reciprocating machines, timed alike theoretically, and connected by a belt. The power curve of each is hopelessly jagged. Only by means of sufficiently heavy flywheels can the sharpnesses of these curves be rounded over.

From the description it is evident that there was insufficient flywheel and belt capacity. The change to a smaller driving pulley was well thought out. It did more than just break up the synchronism, for that would remain to a considerable extent unless a decided speed change was made. The smaller engine pulley increased the mechanical advantage and broke up the critical speed of the belt.

Belts have critical speeds just as shafts do. Changing either the load, speed, or centers will alter the critical speed and the flapping will cease. The critical speed can not well be foretold—it must be demonstrated by the belt's behavior in actual performance. The suggestion on page 479, of the same issue about installing flywheels, is one way of changing loads to bring out the critical speed of a belt.

There are several well defined reasons for a belt's flapping or riding from side to side. They are reaching the critical speed, belt made up wrongly as regards the position the pieces occupied in the hide, a wider belt than necessary, variations in the belt's thickness, and pulsations of the load not properly flywheeled. Each case must be treated as an individual problem since no one rule can be laid down that will correct all the troubles that occur with belt drives.

A belt is a reliable form of transmission, but it seldom gets fair treatment. Applications are made unintelligently and their maintenance frequently neglected. The thought that it is "only a belt" has licensed the most indifferent treatment ever accorded any piece of mechanical apparatus with the result that the belt is blamed for every trouble under the sun.

Compressor drives are truly severe. Wrapper pulleys have been the salvation of many such drives, as the weighted idler automatically damps flapping and regulates the slack caused by sudden changes from no load to full. In the case mentioned, it would have been instructive to have tried twin wrappers before a speed change was made. If the original drive had been well designed, the belt would have been ample to carry the load when the pistons were in the dangerous position and take-up would have cloaked the slack at the opposite extreme. D. A. HAMPSON.

Middletown, N. Y.

The Boiler Unit of Evaporation Should Be Named

Referring to the article in the February 5 number on "The Boiler Unit of Evaporation Should Be Named," by Professor Wm. Jay Dana, and to his suggestion to the A.S.M.E. Power Test Code Committee on Dec. 3, 1928, I would respectfully suggest a "substitute motion," namely, that in the Power Test Codes and in engineering practice, a "bute" be defined as "1,000 B.t.u.," that a "kilobute" be defined as "1,000 butes," or "a million B.t.u.," and that a "megabute" be defined as "one million butes, or 1,000 kilobutes, or one billion B.t.u." One B.t.u. would then be a "millibute."

In my judgment, 1,000,000 B.t.u. is too large a unit as a basic unit for measuring heat, just as the yard and meter are too large as basic units for most industrial uses.

The abbreviations would normally be "mb," "b," "kb," and "meb." As these abbreviations are not now in use, there would be no conflicts or misunderstandings as to their meanings.

This suggestion brings the terms into line with the decimal and metric systems and with millimeters, meters, kilometers, and megameters, and with milliwatts, watts, and kilowatts, and will, therefore, be self-explanatory to an engineer. WM. T. MAGRUDER,

Columbus, Ohio. Professor of Mech. Eng.,
Ohio State University.

REFFERING to the article by Professor Dana in the Feb. 5 issue on "The Boiler Unit of Evaporation Should Be Named," why not use E.U., "evaporation units," to denote the quantity of heat represented by one million B.t.u.?

In the development of electrical science new words were needed and the language is littered with volts, amperes, farads and henries, but in mechanical engineering there has not been the same tendency to provide such words or especially to coin a word for the purpose in question. The term "evaporation units," with symbol E.U., is simple and direct. C. H. CHASE.

Stoneham, Mass.

IN THE ROUTINE CARE OF A LEAD STORAGE BATTERY in service there is no danger to health, but at such times as the battery parts, especially the plates and the sediment, have to be handled in large quantities, the possibility of lead poisoning should be kept in mind and guarded against.

What's New in Plant Equipment

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING TRANSMITTING AND APPLYING THE POWER SERVICES

Fig. 1—Steel band with saw-tooth castings

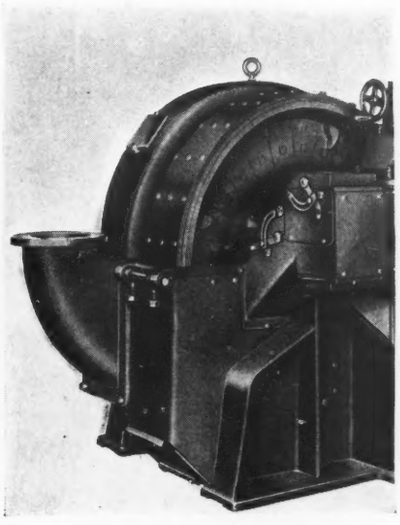


Fig. 2—Pulverizer with the band in place

Changes in Unit Pulverizer Design Improve Reliability and Efficiency

SEVERAL important changes have been made recently to the "Atrita" unit pulverizer which is manufactured by the Riley Stoker Corporation, Worcester, Mass. These changes, it is claimed, have resulted in finer pulverization, reduced power consumption and higher capacities from a given machine. The principal change made to the unit is in the design of the pulverizing chamber. The outer casing has been increased in size to accommodate a heavy steel band in the shape of a horseshoe, as shown in Fig. 1. This band is entirely separated from the casing, except where it is supported at the two ends. To the steel band are bolted castings that not only take the wear, but, because of their shape, have an important part in the pulverizing process. The saw-tooth shapes of the castings are such as to break up the circular motion of the coal and primary air, and, by so doing, reduce the amount of energy wasted in revolving the mass of coal against the periphery of the grinding chamber. The castings are of a size easily handled, and, where the most severe service takes place, they are made of a special wear resisting material. Fig. 2 shows the band in position in a pulverizer.

The heavy unit, cast segment, pulverizing pegs, which have been in use for about two years, are retained. The unit castings are bolted to the rotor with a ferrule insert. The faces of the castings act as wearing plates and protect the rotor.

Improvement has been made to the design of the rotor bearings, a railway type of mounting having been adopted. This consists of a roller bearing, using a tapered sleeve between the inner race and the shaft, insuring accurate fit and preventing movement of the inner race of the bearing in relation to the shaft. Improvement has also been made to the feeder drive. The two-speed clutch of the drive has been changed from the countershaft to the relatively slow-speed worm shaft as shown in Fig. 3. The clutch has been increased in size with correspondingly large contact surfaces, and the shifting mechanism has been changed to prevent overtraveling; that is, in disengaging, the clutch shaft has a positive neutral stop. The magnet of the self-contained magnetic separator has been redesigned. The entire magnet is now enclosed in a brass housing with only the poles exposed.

Fig. 4 shows a No. 5 pulverizer of recent development. It has a rated capacity of 7,500 lb. of coal per hour and a maximum capacity much greater than this. The design follows that of the No. 4 machine except that the housings are made entirely of steel, electrically welded together. The entire unit is mounted on a cast iron sub-base that is extended to provide for mounting the motor. The feeder is equipped with a four-speed transmission, providing four rates of feed.

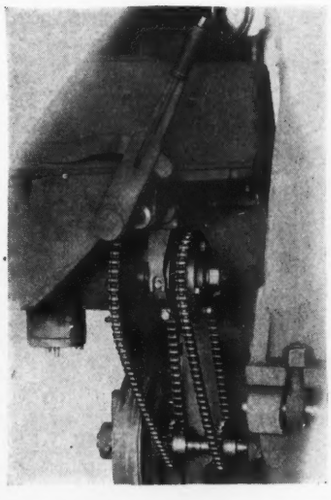


Fig. 3—Two-speed feeder drive

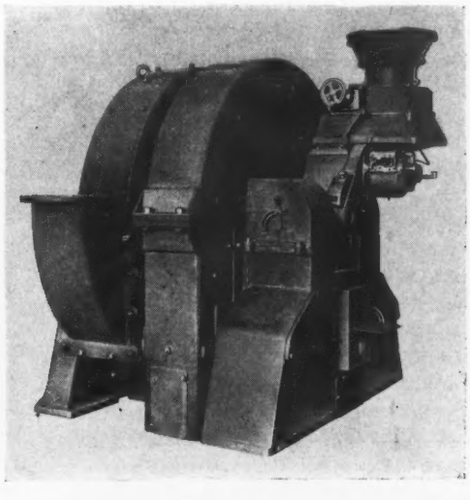


Fig. 4—No. 5 pulverizer with electrically welded steel housing

Vibrex double-deck screen

Improved Vibrating Screen

AN improved double-deck screen, known as the Vibrex, designed for screening fine mesh materials, is announced by the Robins Conveying Belt Company, 15 Park Row, New York City.

The principal improvement made in the design of the screen is the locating of the driving gear or vibrating element in a central position between the two screens midway of the screen's length. This improved vibrating mechanism, which consists of unbalanced flywheels revolving at high speed, producing a vertical circular motion, is designed to give a uniform action over the entire screening surface. Provision is made for varying the amplitude or stroke of vibration so that, with corresponding variations of speed, the best action for the various size openings may be obtained.

As will be clear from the illustration, the screens are flexibly supported from a base frame at each of the four corners by means of springs. The base frame consists of two cross-connected channels, one on either side of the screen, which can be readily bolted to any suitable inclined support. The driving shaft is carried on heavy-duty roller bearings fitted with combination felt and labyrinth seals. The screen cloth is spring cushioned over arched supports, and the angle frames to which the cloth is secured are removable from the main frame as a unit.

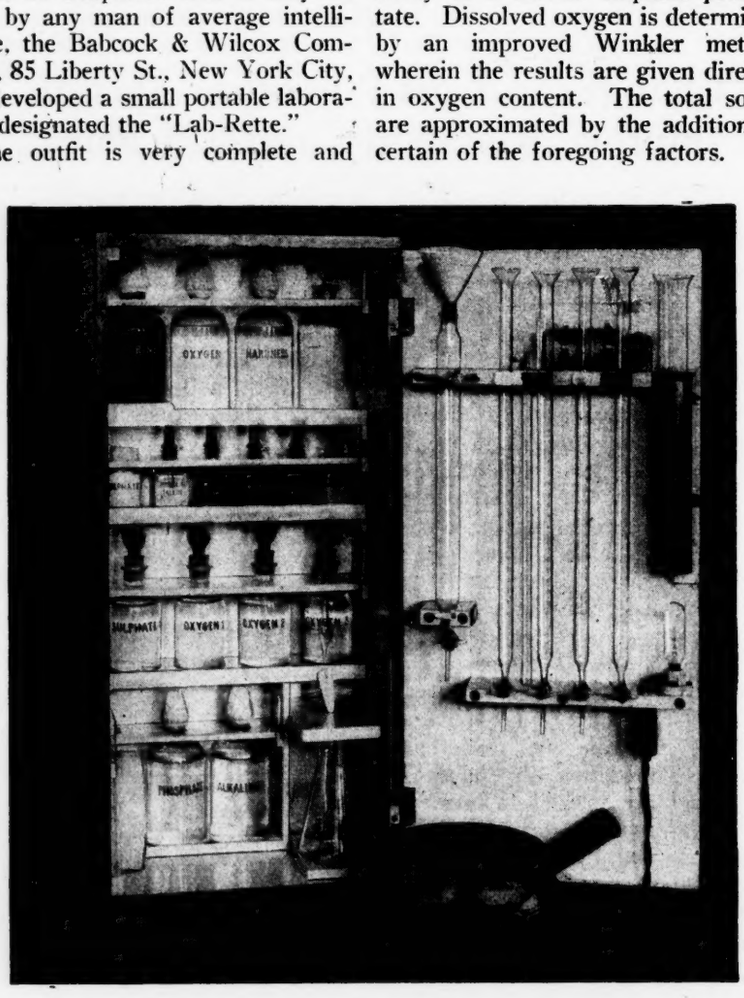
The normal operating speed of the screen is 1,800 r.p.m. with a stroke of about $\frac{1}{8}$ in., and the power required is approximately two horsepower. The Vibrex screen is made both single and double deck and the screen surface on both decks is 42-in. wide by 62-in. long. Where desired the screen may be equipped with a dust-tight housing made in readily removable sections to facilitate screen cloth change. If single screening is desired the lower screen and frame are readily removed from the machine as a unit.

Portable Laboratory for Testing Feed Water

TO MEET the need for a complete method of testing feed water, so simplified that it may be used by any man of average intelligence, the Babcock & Wilcox Company, 85 Liberty St., New York City, has developed a small portable laboratory designated the "Lab-Rette."

The outfit is very complete and when used in conjunction with the manual which accompanies it, makes possible the determination of (1) hardness, (2) chlorides, (3) sodium phosphate, (4) alkalinity, (5) pH value, (6) sodium sulphate, (7) dissolved oxygen and (8) total dissolved solids. The manual goes into such subjects as scale, corrosion, caustic embrittlement, foaming and priming and gives specifications and limits for dissolved solids in the boiler water as well as dissolved oxygen and solids in the feed water. Special attention is given to the treatment of water with soda ash, sodium phosphate and sodium sulphate or their equivalent.

Hardness and chlorides are determined by the usual method. Sodium phosphate is determined by a special method based upon the difference in action of mono-, di- and trisodium phosphate to phenolphthalein and methyl orange. Hydrogen-ion concentration is determined by colorimetric means. Sodium sulphate is determined by a specially constructed sulphate meter which makes use of the turbidity of a barium sulphate precipitate. Dissolved oxygen is determined by an improved Winkler method wherein the results are given directly in oxygen content. The total solids are approximated by the addition of certain of the foregoing factors.



B. & W. "Lab-Rette" for feed water testing

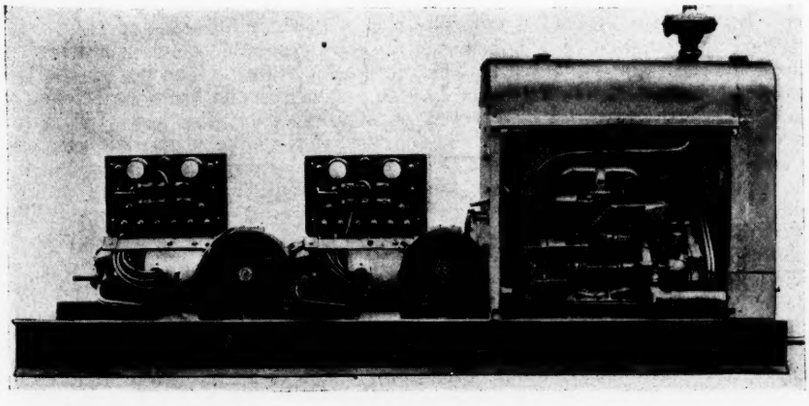
Two-Operator Welding Outfit

WITH a view to reducing the usual power demand of a two-operator welding outfit the Electric Arc Cutting & Welding Company, 152 Jeliff Ave., Newark, N. J., has brought out a two-operator machine with two independent generators operating at 30 volts each instead of one generator operating at 60 volts or above.

This design, it is claimed, makes a more flexible and better operating unit as well as reducing materially the fuel consumption of the engine used to drive the generators. The reason for the reduced fuel consumption is that with a single 60-volt machine of the constant-voltage type, the voltage to the electrodes or arc has to be reduced through resistances, whereas with two 30-volt generators, of the variable-voltage type the voltage can be adjusted at the machine to the proper value to give the best results at the arc. Consequently, the loss due to the resistances or other voltage reducing devices is eliminated.

Two 300-amp. generators are placed in line or on a common channel frame and driven through a common shaft by a 40-hp. Continental four-cylinder engine. The engine is equipped with a large-sized truck-type, six-row tubular radiator and a cooling fan which can be fitted with either ball or sleeve bearings. The engine is connected to the generators through heavy truck-type flexible couplings.

The generators are equipped with transformers for supplying current to lights, drills and grinders. An air compressor is also mounted on a hinged base so arranged as to be lifted easily in or out of gear. Hoods to completely inclose the generators can also be supplied.

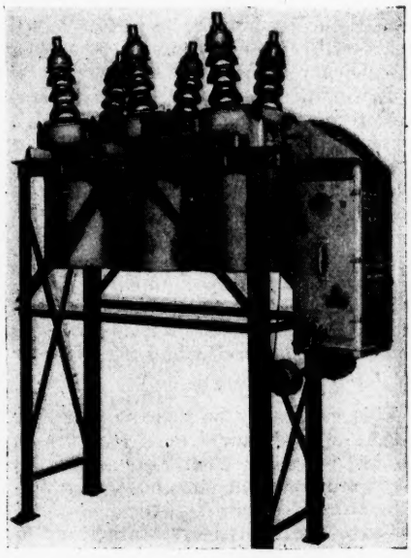


Two-operator welder with two generators and separate controls

Oil Circuit Breaker Has Motor Operated Control

THE Pacific Electric Manufacturing Corporation, San Francisco, Calif., has recently placed on the market its type JC-17 oil circuit breaker. This oil circuit breaker incorporates high rupturing capacity with small physical dimensions. The breaker is designed on the rotary-break principle, a design that has been in use on power systems for over 25 years. The top is cast in one piece, from which all operating parts are suspended, including the motor operator. The rotating member is a heavy blade with arcing tips insulated by a Bakelite tube having wide puncture and creepage margins.

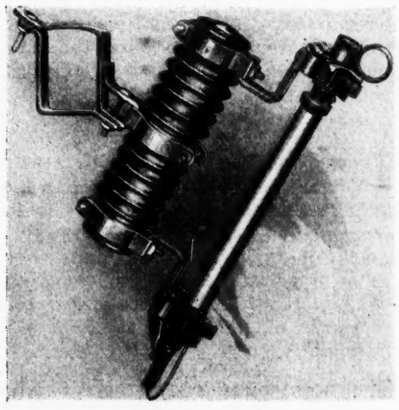
Individual tanks for each phase are bolted to the top with a gasketed joint



Assembly of three-phase breaker

to prevent oil leaks. This form of unit top construction permits the shipping of the breaker as an assembled and tested unit, it being only necessary to make the electrical connections and fill the tanks with oil to place the equipment in service.

The control furnished with the breakers is of the motor wound, spring actuated type, giving high blade speed and positive locking without rebound. An interrupting capacity of 100,000 kva. has been given to the breaker and field tests conducted under conditions set up by the A.I.E.E. show this to be a conservative rating.



Switch with universal crossarm hanger

Line Fuse Switches

A COMPLETE line of 7,500-, 12,000- and 15,000-volt line fuse switches, disconnect switches, fuse-switch-choke-coil combination and disconnect - choke - coil combination switching equipment is announced by the James R. Kearney Corporation, St. Louis, Mo.

These new one-piece porcelain switches are designed so that any switch can be used either as a fuse or disconnect by interchanging the blade or cartridge. The one-piece porcelain used is fog type, having exceptionally high wet and dry flashover. It is mounted in hot-dipped galvanized iron parts.

Resilient inserts are placed between the porcelain and metal rings to eliminate spot loading on the porcelain. The switches are supplied with standard stamped contacts, having special spring clips to give additional contact pressure, or full floating self-aligning standard contacts, or ferrule contacts.

The switch is small and compact so that it takes a minimum amount of space on the crossarm. A universal hanger is supplied with each switch, this one hanger being adjustable for use on any standard crossarm.

FROM AMONG THE READERS'

Conducted
By
L. H. Morrison

THE CO_2 PER CENT WITH PULVERIZED COAL AND STOKER FURNACES. —*Is it advisable to maintain the same CO_2 readings at various boiler ratings in case of both a stoker and a pulverized coal furnace?* R.W.W.

It is customary to have the CO_2 per cent decrease at high ratings in case of pulverized coal firing, for otherwise the high furnace temperature might damage the refractory walls. With stokers over ratings apparently do not show the same damage and the CO_2 can be carried at a constant value.

HORSEPOWER OF MOTOR CHANGES WITH SPEED. —*We have a 5-hp. 3,600-r.p.m. induction motor that is to be rewound for 1,800 r.p.m. The same number of turns and the same size wire is to be used in the new winding as was in the original. What will the horsepower of the motor be with the new winding?* W.M.B.

The horsepower of the motor will vary approximately as the speed. It is proposed to reduce the speed by one half, therefore the power of the motor will be reduced one half, or from 5 to 2.5 hp. If the motor is to operate on the same voltage at 1,800 r.p.m. as it did when running 3,600, then the slow-speed winding will require double the number of turns used in the high-speed winding. This means that the cross-section of the conductors must be reduced by one-half, likewise the full-load current of the motor must be reduced one-half.

As a result of the foregoing, the full-load input to the motor is one-half that for the original winding. With double the number of turns and one-half the current, the stator's magnetic-field density will be about the same as for the high-speed motor. Then, with the same current density in the rotor bars at 1,800 r.p.m. as for 3,600 r.p.m., the full-load torque will be the same for both connections. As power output is a function of the product of the torque and speed, it is readily seen that the horsepower output of the 1,800-r.p.m. motor will be one-half that of the 3,600-r.p.m. machine.

If the 1,800-r.p.m. motor is to be wound with the same number of turns and coils as was the 3,600-r.p.m. machine, then the slow-speed winding will be good for only one-half the voltage of the original winding and will develop one-half the horsepower. The foregoing statements are made on the assumption that both the 1,800- and 3,600-r.p.m. windings are grouped alike and that the chord factor of both windings is the same. A change in grouping the windings or in the chord factor will change the voltage the winding is good for.

HIGH-FURNACE TEMPERATURES. —*Does high-furnace temperature mean high boiler efficiency?* G.D.L.

Generally yes, but not necessarily so. The theoretical combustion temperature with a given fuel depends on the amount of excess air used. The less the excess air the higher the temperature, because the same amount of heat is contained in a smaller weight of furnace gas. Lower excess air means less stack loss, if no CO is present. Thus, furnace temperature is, in a way, an inverse measure of stack loss. However, where furnace temperature is lowered by water-cooled walls, rather than by excess air, no loss in efficiency is involved.

Again, the rise in furnace temperature resulting from the operation of a boiler at higher ratings may actually be accompanied by a falling off in boiler efficiency due to higher stack temperature.

STEAM CONSUMPTION OF A TURBINE. —*Explain the method of determining the steam consumption of a turbine without actually measuring the steam or weighing the condensate.* P.N.B.

This can easily be done with a fair degree of accuracy where the turbine exhaust is superheated, as is sometimes the case with small non-condensing machines supplied with superheated steam. In such cases it is merely necessary to measure the pressure and temperature of the steam before the throttle and after the exhaust.

Suppose, for example, that the throttle steam is at 146 lb. gage and 468 deg., and the exhaust steam at 6 lb. gage and 265 deg. Then the initial steam has an absolute pressure of 146 + 15 = 161 lb., and a superheat of 468 — 364 = 104 deg. The total heat is given in the Marks and Davis steam tables as 1,253 B.t.u. In the same way the exhaust conditions are found to be: 21 lb. abs., 35 deg. superheat and 1,174 B.t.u. The heat drop is then 1,253 — 1,174 = 79 B.t.u. Since this heat drop is turned completely into power (except for radiation from the machine) and since 2,545 B.t.u. equals one horsepower-hour, the steam used per horsepower-hour is slightly more than 2,545 ÷ 79 = 32 lb. per horsepower-hour.

Where the exhaust is wet the same method would be theoretically correct, but great difficulty would be found in making a correct measurement of the moisture for determination of the total heat in the exhaust. Even the temperature measurement requires care.

VOLTAGE OF ROTARY CONVERTERS.—*What is the relation between the voltages on the direct-current and alternating-current ends of a rotary converter?* M.E.W.

In a single-phase, quarter-phase or six-phase diametrically connected rotary converter, the voltage on the direct-current side is equal to that at the collector rings divided by 0.71. For a three-phase double-delta connected rotary converter, the voltage at the commutator is equal to that at the collector rings divided by 0.61.

STOPPING CORROSION IN BOILERS.—*We have in our plant two 1,500-sq.ft. return tubular boilers operatng at 140 per cent rating. We have trouble with corrosion, the water actually having a reddish tint in the glass, when the water column is blown down. The old scale in boiler has also turned from white to pink. We never had this trouble before installing a feed-water softener.*

The water from the softener has been analyzed, as follows:

Total alkalinity	*3.2*	*Grains per gal.*
Acidity	*none*	
Chlorides	*2.9*	
Iron	*trace*	
Sulphates	*trace*	
Oxygen per liter	*6.1 c.c.*	

We have a closed-type vented feed-water heater, and carry a feed-water temperature of 150 deg. What effect would zinc bars have suspended in boiler? A. M.

THE extensive corrosion in your boiler probably results from the combined effect of the chlorides and dissolved oxygen. Before installing a softener your boiler surfaces were protected from corrosion by scale.

The first step is to check up with the manufacturer of the softener to see that it is properly operated. Then take steps to reduce the dissolved oxygen to the lowest possible point by raising the feed temperature. The nearer the feed temperature in the heater is brought to its boiling point the less will be the oxygen left in the water. If increased feed temperature does not solve your problem, experiment with the venting. As a last resort it may be necessary to install an open heater, preferably of the deaerating type.

It has been definitely shown that elimination of dissolved oxygen from ordinary feed water prevents corrosion.

Opinions differ as to the value of zinc. You could try it out at little cost and settle the point as far as your case is concerned.

PROBLEMS

ANSWERS

from Our Readers

THE QUESTION

WILL there be a loss in its heating value if coal is stored under water? What is the cause of the difference?

P. G. S.

NO APPRECIABLE change in heating value takes place in submerged storage. Outdoor exposure results in a loss of heat value varying from 2 to 10 per cent.

The effect of weathering on coal is to diminish the carbon and available hydrogen content and to increase the oxygen and unavailable hydrogen, thus reducing the calorific value.

An excess of pyrites in coal exposed to the atmosphere tends to produce rapid oxidation and mechanical disintegration of the mass, with consequent development of heat, loss of coking power and spontaneous ignition.

EUGENE OGDEN.

Jeffersonville, Indiana.

EXPERIMENTS show that the heating value of coal stored in the open air decreases very little due to weathering. The outside of a storage pile undoubtedly weathers to some extent and tends to break down in smaller pieces. The higher grades of Eastern coals do not have this tendency to break down and for any reasonable length of time of storage do not show a loss of heating value.

Spontaneous combustion is the result of accumulation of heat due to slow oxidation of coal. Coal slowly ozidizes on exposure to air.

The real cause of the heating seems to be in the coal itself. Fine coal or screenings are more liable to spontaneous combustion than sized coal and much more attention should be given to screenings than larger coals. The oxidation of coal that takes place in contact with the air depends upon the surface exposed.

Since oxidization of the coal tends to produce spontaneous combustion, air should be excluded from the coal where practicable. Under-water storage of coal gives complete protection in this respect. The elements of cost and inconvenience, however, enters into this type of storage.

If it is required to store large tonnages of some grades of coal that fire easily, under-water storage is almost a necessity. A number of Western sugar factories burning Wyoming coal store their coal under water.

The results of experiments at the University of Illinois show that submerged coal does not lose appreciably in heating value. G. A. GLICK.

Sheboygan, Wis.

COAL does not lose appreciably in heat value when stored under water. From one to two per cent in heating value can be saved with under-water storage as against storage in the open air. Water excludes the air and greatly reduces oxidation. Consequently the excluded gases are retained over longer periods of time. Again the coal is not much affected by weather changes, with consequent reduction in the amount of slack.

It is seldom that coal is stored under water primarily for saving in heat value, however, but rather to prevent spontaneous ignition, against which under-water storage is 100-per cent protection.

In the above I refer to bituminous coals only, as anthracite is not so affected. R. G. SPOONER.

New Bedford, Mass.

WITH coal stored under water there will be practically no change in the heat value figured on the dry basis. But, from experimental data, it has been proved that coal will absorb from two to twelve per cent moisture, depending on the coal. Illinois and Wyoming coal will absorb more than the high-grade Eastern coal. Therefore, we get a loss in heating value of the coal, as fired, due to the greater moisture content.

Data are available for a large plant in Chicago, which has a submerged coal bin where the coal is kept covered with water, primarily for protection from spontaneous ignition. Analysis of coal at this plant for two years, both from under-water and open-air storage, shows an advantage of 1.9 per cent in the "as-fired" heat value in favor of the coal stored under water. This shows that the loss by oxidation of coal stored in air is greater than the loss due to the greater moisture content of coal stored under water. J. M. LYLE.

Louisville, Ky.

COAL stored under water does not lose appreciably in heat value, because after it is submerged in the water it does not absorb the oxygen in the air. The more oxygen coal absorbs after it is mined the lower will be its heat value.

Analysis of coal stored under water shows about two per cent higher heat value than coal stored in the open, but from one-half to one per cent of the heat in the coal will be required to evaporate the added moisture.

So far as conserving the heat energy in coal is concerned, some might be saved by storing it under water, but that method of storage would prove impracticable in most cases.

Coal is stored under water primarily for protection from spontaneous ignition. It also helps greatly to prevent segregation of the fine and coarse coal, which is very important.

Alberta, Canada. W. TATTERSALL.

A Question For Our Readers

WHAT causes elevator cables to swing in the hoistway? On one elevator in my charge the hoist cables running from the drum to the overhead sheave have a tendency to swing. One of these cables broke at the socket in the car's crosshead, apparently because of the swinging action. If the brake is adjusted to allow the car to drift considerably when making stops, the swinging of the cables is materially reduced. The trouble does not occur continuously. If the operator handles the control carefully the swinging of the cable can be largely avoided. C. R. M.

Suitable answers from readers will be paid for and published in the May 7 issue.

Effect of Alloying Elements Upon Stability of Steel

At Elevated Temperatures

Excerpts from a paper before the A.S.M.E. by A. E. White and C. L. Clark of the Department of Engineering Research, University of Michigan. The findings are based on tests of nineteen different alloy steels, the details of which are given in numerous tables, curves, and microphotographs in the original paper.

FOR a metal to be serviceable at elevated temperatures it must be stable at the temperatures employed. When a metal is stable, two distinct characteristics are implied:

1. That the metal or alloy is capable of resisting oxidation at the temperatures considered.

2. That the metal or alloy is capable of resisting indefinitely, or at least for the economic life of the piece of which it forms a part, the stresses to which it is to be subjected.

Resistance to Oxidation

If the resistance to oxidation is to be increased, some alloying element must be added which is itself resistant under the given conditions and which, when added to the steel, dissolves in the ferrite. Two corrosion-resistant elements which may be considered in this connection are nickel and chromium. Nickel, when added to steel, dissolves in the ferrite and so increases the ability of the metal to resist either oxidation or corrosion. Chromium, on the other hand, has a greater affinity for the carbon than the ferrite. Thus, if added in small amounts, it will combine entirely with carbon and form carbides, and the resistance to oxidation is not increased unless the steel is subjected to a heat treatment to throw off the carbides, at least partly, into solution. If, however, the carbon is sufficiently low and the chromium is added in large enough amounts so that there is more than enough chromium to combine with the carbon, then the remaining chromium will dissolve in the ferrite and the resistance to oxidation is increased without any heat treatment.

As an example of the latter two cases, chromium stainless steels, containing approximately 12 per cent chromium and 0.30 per cent carbon, require a heat treatment to give them oxidation-resisting properties, while the stainless irons, containing approximately 12 per cent chromium and 0.10 per cent carbon, resist oxidation without any previous heat treatment.

Load-Carrying Ability

It is well-established that at atmospheric temperature, fracture of ordinary steels proceeds through the grains and not around them. This is owing to the greater strength of the amorphous boundaries. As the temperature of testing is increased, however, the amorphous phase weakens at a more rapid rate than that of the crystal proper, and a temperature is finally reached where fracture proceeds around the grains and not through them. This temperature Jeffries calls the "equicohesive temperature." In general, under very slow rates of loading, this corresponds to the lowest recrystallization temperature of the alloy when in a severely cold-worked state. Values for recrystallization temperatures reported in the literature vary considerably, but that generally accepted for commercial iron is in the neighborhood of 850 deg. F. (454 deg. C.)

It is evident that before the effect of alloying elements upon the load-carrying ability of metals can be determined, it will be necessary to know over what temperature range and for what length of time this stability is desired. That is, for plain carbon steels those elements the addition of which may cause increased stability up to temperatures in the neighborhood of 850 deg. F. (454 deg. C.) are not necessarily the ones that will have the greatest effect in increasing the load-carrying ability at the higher temperatures.

If stability is desired below the equicohesive temperature, then we advance the following hypothesis:

1. The addition or formation of any element, compound, or constituent which does not enter into solid solution with the matrix, but which by the very nature of its presence interferes with the crystal slippage, will tend to increase the load-carrying ability of the material of which it forms a part.

2. The addition or formation of any element, compound or constituent which tends to increase the amount of amorphous material will increase the load-carrying ability of the material of which it forms a part.

For stability above the equicohesive temperature, our hypothesis follows:

1. The addition or formation of any element, compound, or constituent which tends to decrease the relative proportion of amorphous material to crystalline material will increase the load-carrying ability of the material of which it forms a part.

2. The addition or formation of any element, compound or constituent which strengthens the grain boundaries by interfering with plastic flow will increase the load-carrying ability of the material of which it forms a part.

Methods of Present Investigation

For the purpose of obtaining the data from which the factors producing stability at elevated temperatures could be determined, short-time tensile tests were conducted on a large number of alloy steels.

The steels were subjected to short-time tensile tests at temperatures as high as 1,500 deg. F. (816 deg. C.) in some cases and to 1,250 deg. F. (677 deg. C.) in others. The last five were tested after various heat treatments only at 1,000 deg. F. (538 deg. C.).

It is realized that proportional-limit values as obtained in short-time tensile tests may not be, at temperatures above the equicohesive temperatures at least, a true criterion of a metal's load-carrying ability. Yet it is believed that for temperatures not too far above this point carefully determined proportional limits can be used as a good measure of the metal's ability to resist rupture for periods up to several thousand hours.

Some question arises in high-temperature testing as to just what heat treatment should be applied to the metal before subjecting it to the testing process. It has been shown several times that in all tempering or drawing operations

at least two factors must be considered, (1) the temperature employed and (2) the time during which the metal is maintained at that temperature. Therefore, if it is desired to subject the specimens to any sort of a quenching operation, it is necessary to draw them at a sufficiently high temperature so that the time effect at the temperature at which they are to be used will not cause any marked change in structure with corresponding changes in physical properties.

Because of the necessity of following any quenching treatment with such a high degree of tempering, all the metals on which tests were conducted at temperatures above 1,000 deg. F. (538 deg. C.) were subjected to either a normalizing or an annealing treatment. It is felt that these two treatments more nearly represent the working conditions encountered in service.

If, however, the metals are to be used at only relatively high temperatures, such as 1,000 deg. F. or possibly 1,100 deg. F., then quenching operations followed by a suitable draw will often result in greatly improved load-carrying properties at these moderate elevated temperatures. With this in view six selected steels were subjected to various heat treatments and then tested at 1,000 deg. F.

Nickel Steels

Nickel dissolves in steel at atmospheric temperature, especially in the ferrite crystals. Since nickel additions produce a marked lowering of the thermal critical range of iron, slowly cooled nickel steels can have various structures, as pearlitic, martensitic, or austenitic, depending on the relative amounts of nickel and carbon present.

With low-carbon nickel steels in the pearlitic zone, one of the effects of the addition of nickel is to reduce grain size. At atmospheric and slightly elevated temperatures this reduced grain size improves the strength of the alloy due to the presence of larger amounts of amorphous material. At elevated temperatures above the equicohesive temperature this reduced grain size results in a weakening of the alloy if the rate of application of the load is very small, due to increasing the amount of the weakest phase (amorphous) present.

Plain nickel steels in the normalized state do not offer possibilities of having high load-carrying ability at temperatures much above 750 deg. F. (399 deg. C.). Neither should various heat treatments be expected to increase greatly the stability of low-nickel steels at temperatures in the neighborhood of 1,000 deg.

Chromium Steels

Chromium dissolves in iron in all percentages, forming solid solutions with the ferrite. In the presence of carbon, however, it forms double carbides with the iron. The carbides that are deposited within the crystal will interfere with the process of crystalline slippage, and for that reason materially increase the stability of the alloy at all temperatures below the equicohesive temperature. The carbides which are precipitated at the grain boundaries will interfere with the plastic flow of this material, and so increase the load-carrying ability of the metal above the equicohesive temperature. Therefore steels which contain chromium in sufficient amounts manifest a much greater load-carrying stability at all temperatures than plain carbon steels or nickel steels.

Likewise, compositions which produce the free carbides show greater strength in the alloys in which they are found than compositions which throw the carbides into solid solution, as evidenced by the superior results of 8 per cent chromium, 8 per cent tungsten steel over and above those of two alloys, one containing 20 per cent chromium and 8 per cent nickel and the other 8 per cent of chromium and 20 per cent of nickel. To be sure, in the first case 8 per cent tungsten is present and in the other two relatively large percentages of nickel, but the structure of the first steel shows free carbides, while the last two are austenitic—solid-solution alloys.

The best criterion for the stability characteristics of these alloys are studies at 1,000 deg. F. and higher. Under such conditions the steel containing 7.93 per cent chromium and 7.7 per cent tungsten stands out above all the others.

Chromium-Nickel Steels

The addition of both chromium and nickel to a steel should give an alloy having properties which are a combination of those mentioned in the foregoing two cases. Nickel dissolving mainly in the iron will increase the resistance to oxidation of the alloy, while the chromium, being a former of carbides, will tend to increase the load-carrying ability of the alloy. Since nickel additions will produce a marked lowering of the thermal critical range of the iron, the same varieties of structure obtained in the case of straight nickel steels are again possible.

Short-time tensile tests were conducted on four chromium-nickel steels, two containing small enough amounts of the alloying elements so that in the annealed condition their structures were pearlitic, and two containing such large amounts of both chromium and nickel that even in the annealed state they were austenitic.

A comparison of the properties obtained with these four steels showed that if the best results, in regard to load-carrying ability at moderately elevated temperatures, are to be obtained, then the amounts of alloying elements added must not be sufficiently large to cause the steels to become austenitic.

Tungsten combines with the carbon rather than with the iron when added to steel. Since it is similar in this respect to chromium, the tungsten steels should be expected to have load-carrying properties comparable to those of the chromium steels. A comparison of the results obtained with these two steels shows the tungsten-bearing steel to have the superior properties, especially at the higher temperatures.

Chromium tungsten steels, owing to the presence of two carbide-forming elements, should exhibit good load-carrying properties at temperatures both above and below the equicohesive temperature.

Manganese Steels

Manganese is similar to both chromium and nickel in that when added to steel it unites with the carbon, forming double carbides, and also dissolves in the ferrite. The separation of free carbides is not obtained unless both the carbon and manganese are present in relatively large amounts. For this reason the addition of this element should increase the load-carrying ability of metals at elevated temperatures, but not to such a degree as chromium or tungsten.

Molybdenum and Vanadium Steels

Molybdenum and vanadium, in that they combine with the carbon to form carbides when added to steel, are both similar to chromium and so should, like chromium, increase the load-carrying ability of the alloys to which they are added. They both differ from chromium in that smaller percentages of these elements are required to produce the same change as in the case of the chromium alloys.

Vanadium in that it is a grain refiner is similar to nickel. In this respect it will, like nickel, increase the load-carrying ability at temperatures below the equicohesive temperature, but for temperatures above will have the opposite effect. It is also claimed that vanadium is beneficial in that it reduces intercrystalline brittleness, a condition often encountered in heat-resisting alloys.

Chromium-Aluminum Steel

The effect of heat treatment upon the tensile properties at 1,000 deg. F. of a chromium-aluminum steel was also investigated. The aluminum, dissolving mainly in the iron, was not expected to affect greatly the load-carrying ability, but it was desired to determine the joint action of both chromium and aluminum on the high-temperature properties of steel.

The hardness of this alloy can be varied considerably, depending upon the heat treatment. The increased hardness can be accounted for on the assumption that either the chromium carbides or else complex compounds of chromium, aluminum and carbon are either partly or wholly dissolved in the ferrite as the quenching temperature is raised. In the case of the normalized specimen all the carbon and chromium seemed to have disappeared, and must have been in solution in the polyhedral crystals.

Studies of Moisture in Steam at High Rates of Evaporation Presented at A.S.M.E. Meeting

THE separation of entrained moisture in the steam before it leaves the boiler drum is now a problem causing some concern in the operation of large boilers at extremely high ratings. A paper giving the results of some studies made on this problem at the Kips Bay Station of the New York Steam Corporation was presented by A. M. Mumford at a meeting of the Metropolitan section A.S.M.E. on Monday evening, April 1.

The boiler on which the studies were conducted (between November, 1927, and January, 1929) is a six-drum unit with two main steaming sections (Ladd Type) placed vertically on 19-ft. 2-in. centers. The top drums of these units are 48 in. in diameter and the lower ones 42 in. A 30-in. dry drum is mounted centrally above the two upper drums and connected to them by curved tubes. The lowest drum forms the mud drum and is connected through a floor screen to the vertical front water walls of the furnace. The furnace is completely water-cooled, as are also the two side walls of the boiler proper. The problem was the reduction or elimination of moisture in steam from boilers operated at rates of 25 lb. evaporation per square foot of boiler and furnace surface with 90 per cent makeup and full chemical treatment in the boiler for the elimination of scale. Excerpts from Mr. Mumford's paper follow:

The first series of studies constituted a search for variables other than capacity, on which the moisture quantity depended. Water level was found to be a minor factor in the problem within the range of normal operation. One or two studies showed reasonable and consistent agreement between variations in water level and variations in moisture, but for the greater number of the studies it was found that the amount of water level variation normally occurring was not sufficient to affect the calorimeters.

Calorimeter Readings Varied Widely

The first variable studied was the design of calorimeters and sampling nozzles. It was found that the number of measurements of moisture in a given steam main varied directly with the number of different calorimeters installed and also directly with the number of different locations of the same design of calorimeter and sampling pipe. The calorimeter problem was eventually solved by standardizing both design and location on the basis of the highest moisture indication of the various types.

Following this a second variable, that of the addition of chemical for scale prevention in the boiler, was investigated and then temporarily abandoned as one of the factors in the moisture problem. The results indicated that the moisture was slightly greater when the chemical was fed at zero than when it was fed at maximum rate. Later, when the studies interrupted by construction work were continued, the critical value of the concentration of the hydroxyl radical was found, but in the interim the use of mechanical means such as baffles, etc., to reduce the moisture was studied.

Several types of baffles were tried in the 48-in. drum including those of the deflector and louvre type, designed to remove the moisture by impingement and also by changing the direction of flow. Most of the baffles tried represented types that had accomplished really satisfactory results elsewhere and could be reasonably expected to improve the conditions encountered at this plant, but they did not do so. All tests were made with care, and only one of the known variables affecting moisture was studied at one time.

Following these experiments with baffles, studies were conducted to show the effects of the concentration of hydroxyl on the moisture content. These studies showed that there is a critical concentration of hydroxyl, the value of which for the particular boiler under test is somewhere between the limits of 220 and 250 parts per million. It was also found that the concentration of hydroxyl varied independently of the concentration of other dissolved solids in the boiler water of the bent-tube boiler, and yet when the hydroxyl concentration reached the range of the critical value, the amount of moisture in the steam almost invariably increased. The effect of the critical concentration of hydroxyl has been the same in boilers just filled with raw water as it was on boilers that had been on the line for weeks, so that the effect of hydroxyl must have been independent of the concentration of suspended matter, which must have varied under those conditions. Furthermore, several hundred concentrations of the raw water showed no organic matter when made acid and subjected to ether extraction, so that saponification is not the obvious reason for the action of hydroxyl in this case.

The effect of rate of evaporation on moisture was next studied. After considerable experimenting had been done, with increased size of purifier drains, to decrease the drainage resistance, a new type of baffle was again tried with satisfactory results. This baffle consisted of a perforated plate placed at an angle in each 48-in. drum. With this baffle in place the calorimeter temperatures remained practically constant at ratings up to 22.5 lb. per sq.ft. of heating surface, and the moisture was found to be less than ½ of 1 per cent.

In conclusion Mr. Mumford pointed out that the foregoing thoughts are based on the assumption that the condition of the fluid in any boiler is the same at all points of the heating surface where the rate of evaporation is the same, and is of the nature of an emulsion or fine fog increasing in emulsification or fineness as the rate of evaporation increases. If this assumption is acceptable, then the moisture problem can be solved by designing the steam path so that the mist is coalesced into droplets separable by gravity. This coalescence can be accomplished by impinging the fluid at high velocity on targets or by combing the moisture through small apertures. The only other requirement is that sufficient drainage be provided to remove the water as soon as it is separated.

Conclusions Drawn From the Studies

The conclusions drawn from these studies were given by Mr. Mumford as follows:

First, that the concentration of the hydroxyl radical is a factor in the production of wet steam which acts independently of the rate of evaporation or of the concentration, within the range of these studies, of other solid or dissolved chemical substances, and which has a critical value varying with the boiler design.

Second, that the production of dry steam at high rates of evaporation is partly a problem of re-entrainment of the separated water due to inadequate drainage.

Third, if the assumption that the physical condition of the mixture of steam and water on any boiler-heating surface varies only with the rate heat is being absorbed by that surface is acceptable, then the problem of moisture elimination is reduced to a problem of steam path applicable to boilers in general.

Written discussions of the paper, prepared by W. A. Shoudy and G. K. Saurewein, were read by R. M. Gates. Written discussions were also presented by G. A. Orrok and N. Artsay. Mr. Orrok was of the opinion that the concentration of solids in solution causing saponification was more responsible for the priming or entrainment of moisture than the concentration of the hydroxyl radical. Somewhat the same opinion was expressed by Henry Kreisinger, who considered that the simplest way to overcome the trouble was to reduce the concentration.

R. J. S. Pigott said he could not agree with Mr. Mumford as to the advantage of baffles for removing moisture from the steam and cited his experience with large separators at the Fifty-ninth Street Station of the Interborough Rapid Transit Company. In two instances separators which were filled with baffles, gave practically no drying until the baffles were removed. When this was done the moisture in the steam was reduced 75 per cent. In one large separator, which was particularly effective, the steam velocity was reduced to 30 ft. per sec. He was of the opinion that impingement was ineffective, but that the change in direction of flow was effective.

Events and Men in Power's Field

THE EDITORS WILL WELCOME THE CO-OPERATION OF READERS IN REPORTING INTERESTING HAPPENINGS, PERSONAL OR OTHERWISE

Welding Society Announces Spring Meeting Program

Subjects Include Welding Schools, Pipe Joints, Steel Structures and Applications of Welding to Heating and Ventilation and Process Industries

THE organization of welding schools, physical properties of butt welds, welded pipe joints, design of joints for welded steel structures, welded pressure vessels, welding in the heating and ventilating industry and a symposium on welding in the chemical and process industries are subjects on the program of the annual meeting of the American Welding Society, which will be held in New York City, April 24-26. These are listed in a preliminary announcement just released by the society. Other papers will concern air craft welding and rail joints.

The paper on welding of pressure vessels for high pressures and temperatures will be of considerable interest to power engineers.

The symposium on welding schools will be of broad general interest because of the demand for skilled welders.

Papers already listed in the symposium on welding in the chemical and process industries include the welding of aluminum, nickel and monel metal.

A stag dinner with special entertainment has been arranged for the evening of April 25. The complete program follows:

WEDNESDAY, APRIL 24, 1929

Morning

Technical and Business Sessions

10:00 a.m. to 10:30, Room 2, 5th Floor, Business Meeting, F. T. Llewellyn, President, Presiding.

Report of President, Report of Tellers' Committee, Election of Officers, Presentation of Miller Medal.

10:30 a.m. to 12 noon, Room 2, 5th Floor, Technical Session.

A symposium on "How to Organize and Operate an Industrial Welding School."

Afternoon

Technical Session

2:00 p.m. to 5:00, Room 2, 5th Floor, Technical Session, F. M. Farmer, Presiding.

"Physical Properties of Butt Welds," by G. Lobo, Westinghouse Electric & Manufacturing Company.

"Welded Pipe Joints" (author to be announced later).

Evening

Board of Directors Meeting

Meeting of Board of Directors of American Welding Society. Appointment of committee chairmen and other officers. Committee reports. Plans for the coming year.

THURSDAY, APRIL 25, 1929

Morning

Technical Session

10:00 a.m. to 12, Room 2, 5th Floor, F. T. Llewellyn, President, Presiding.

"Design of Joints for Welded Steel Structures" by A. Vogel, General Electric Company.

"Welding in the Heating and Ventilating Industries" by Prof. S. E. Dibble, Carnegie Institute of Technology.

Afternoon

Technical Session

2:00 p.m. to 5, Room 2, 5th Floor, A. G. Oehler, Presiding.

"Welding in the Aircraft Industry" by R. M. Mock, Bellanca Aircraft Corporation.

"Thermit Welding of Rail Joints for Main Line Track of Steam Railroads" by J. H. Deppeler, Metal & Thermit Corporation.

Evening

Annual Dinner

The dinner, as last year, will be arranged as a stag affair with special entertainment. Tickets $6.00 per person.

FRIDAY, APRIL 26, 1929

Morning

Technical Session

10:00 a.m. to 12, Room 2, 5th Floor.

A Symposium on Welding in the Chemical and Process Industries.

"Welding Aluminum in the Chemical Industry" by W. M. Dunlap, Aluminum Company of America.

"The Production of Ductile Welds in Nickel and Monel Metal" by N. B. Pilling, International Nickel Company.

"Welding in the Gas-Handling Industry and Requirements of Welding in the Chemical Field" by R. S. McBride, Assistant Editor, *Chemical & Metallurgical Engineering.*

"Welding of Pressure Vessels for High Temperature and Pressures" by T. McLean Jasper, A. O. Smith Corporation.

Afternoon

Annual Meeting

American Bureau of Welding

2:00 p.m. to 3:45, Room 3, 5th Floor, C. A. Adams, Director.

Review of progress made by various research committees of the Bureau. Plans for future investigational activities. Election of Officers. Appointment of Executive Committee.

3:45 p.m. to 5:30, Room 3, 5th Floor.

Meeting of Structural Steel Welding Committee, J. H. Edwards, Chairman.

World Conservation Conference Is Suggested

In an open letter to President Hoover, Gifford Pinchot, acting for the Committee to promote an inventory of the natural resources of the world, suggested that an International Conference be called to provide for an inventory of all natural resources, and to discuss the common interests of nations involved in policies of conservation of such resources. The letter was signed by 175 men and women interested in the project.

It recalled the efforts of Theodore Roosevelt, who, when President in 1909, invited the nations to participate in a World Conservation Conference to be held at the Hague. The opinion was expressed that the proposal should be revived and carried to completion by the country of its origin.

Men in the News

J. F. LINCOLN

formerly vice-president of The Lincoln Electric Company, has been elected president of that company. Since 1912, when he became general manager of the company, Mr. Lincoln has been an outstanding figure in the electrical industry. He was among the first to envision the enormous possibilities of electric arc welding as a manufacturing tool as contrasted with a process for salvage and repair.

Control of Surplus Power in Maine

Surplus hydro-electric power exportation by modification of the Fernald law is a major issue now before the Maine Legislature. The principal operating companies favor the Carlton bill, under which transmission companies would have the right to purchase and sell energy outside the state on approval of the Maine Public Utilities Commission, which would determine the available surplus and certify it for export after the reasonable needs of the Maine market were supplied. The bill carries a referendum to next fall's election and closely resembles the Smith bill of two years ago, which was vetoed by former Governor Brewster. Very little new material on this long-debated question was brought out at recent joint committee hearings in Augusta, but the opposition to exportation of surplus power appears weaker than it has been.

Busch-Sulzer Elects New Officers

At a meeting of the board of directors of the Busch-Sulzer Bros.-Diesel Engine Company, held on March 28, August A. Busch was elected chairman of the board. Edward B. Pollister was elected president, succeeding Mr. Busch; and C. Drummond Jones, formerly fourth vice-president, was elected second vice-president to succeed Mr. Pollister.

New Brunswick Plans Steam Standby Stations

In the annual report of the New Brunswick Electric Power Commission, it is stated that preliminary plans have been formed for the building of a modern auxiliary fuel plant so situated as to be of help to the present hydro system. In pointing out the need for such a plant, the report predicts that whereas more than 26,000,000 kw.-hr. were distributed last year a total of not less than 60,000,000 kw.-hr. will be needed by 1937 and, with present facilities, the commission is not in a position to supply this.

Huge Tunnel for Scottish Power Scheme Completed

What is said to be the largest waterway tunnel of its kind in the world has recently been opened between Fort William and the valve shaft at Lochtreig, Scotland. It is fifteen miles long and was driven through the Ben Nevis mountain range.

The main purpose of the tunnel is to provide water power for the manufacture of aluminum by the British Aluminum Company, but there will be a large surplus of power for supplying the needs of the entire surrounding community. These works, the cost of which runs into several million pounds, are designed for a total development of 120,000 hp.

*Spot * News*

PRESIDENT HOOVER *will receive the John Fritz medal at a special presentation on April 25. The award is to be made at Washington, D. C., by the American Society of Mechanical Engineers.*

* * *

THE CENTRAL ELECTRICITY BOARD OF GREAT BRITAIN *has started active reorganization of the generation and transmission of electric power throughout England, Scotland and Wales. While several years will be required to complete the system of co-ordination, the Board expects to supply electricity on a small scale to southeast England and central Scotland areas before the middle of 1929. Under this program, contracts for supplies and equipment to the amount of £3,000,000 have been placed.*

* * *

SO SUCCESSFUL *has the 7,000-kw. municipally owned lighting plant at Hamilton, Ohio, proved to be that profits from the sale of power are claimed to be sufficient to pay for an additional 7,000-kw. unit. Municipal officials are urging this addition at once, together with the discontinuance of stand-by service by a near-by public utility. The Hamilton plant cost $900,000.*

* * *

THE ATOMIC HYDROGEN WELDING PROCESS *is now applicable to aluminum and other light alloys, according to Peter P. Alexander of the Thomson Research Laboratory of the General Electric Company, Lynn, Mass. All but very thin sheets of aluminum can be welded by this process.*

* * *

THE MANUFACTURE *of industrial alcohol for use in internal combustion engines has been started on a commercial scale in Queensland, says the Chemical Division, U. S. Department of Commerce. The alcohol is being made from sugar-cane waste, and can be used alone or in admixture with gasoline.*

* * *

THE LARGEST *of all oil circuit breakers is on order with the Westinghouse Electric & Manufacturing Company, according to a recent bulletin. The apparatus will stand 25½ ft. high, will be 45 ft. long, and will contain 22,000 gal. of oil, weighing altogether 141 tons. It will be insulated for 250,000 volts, and will be used by the Public Service Gas and Electric Company of New Jersey.*

* * *

ATTORNEY GENERAL MITCHELL *has informed leaders of the oil industry that the federal government has no authority to sanction their proposal to limit crude-oil production in 1929 to the output of last year.*

Power Development for Gold Belt Area

The Ontario Hydro Electric Power Commission has plans for the installation of a 5,000-horsepower unit at Ear Falls, on the English River, for the purpose of supplying power to mining enterprises in that district. This is only one phase, it is said, of an extensive scheme of making electrical energy available to all sections of the 190-mile gold belt area between Red Lake and Fort Hope. Two power sites figure in the Commission's present development scheme: The Ear Falls one, and another at Manitou. The first site is capable of generating 30,000 hp., although only 5,000 hp. is slated for harnessing in the initial move of the commission. At Manitou some 50,000 hp. can be developed.

American Bid Highest in Shanghai

A bid of approximately $50,000,000, by the American and Foreign Power Company, of New York, was highest among sealed bids for purchase of the municipal electric plant of the International Settlement at Shanghai, China. The next highest bid was that of $36,000,000 by the British Trusts Associated, Ltd. It is understood that the American firm's bid is underwritten by the Electric Bond & Share Company, of New York.

The result of the bids is considered of international commercial and political importance because it foretells the end of British control of electric development in China, which has for many years obstructed American entrance into this field. Although the sale of the municipal plant has to be submitted at the annual rate payers' meeting this month, approval is almost a foregone conclusion because the American bid would more than wipe off the entire bonded debt of the international settlement.

Atlanta to Have 100,000-hp. Steam-Electric Plant

Plans are being made by the Georgia Power Company for the construction of a 100,000-hp. steam-electric power plant on the Chattahoochee River, near Atlanta, which will be the largest of its kind in Georgia and among the largest in the country, according to a recent announcement. It will be the largest single development undertaken by the company since the completion of the Tallulah Falls unit in 1913, it is said, and will serve as an auxiliary plant capable of bearing the entire electric load of the Atlanta metropolitan district. The plant will be linked with the general hydro-electric system of the company in north and central Georgia, and with large power projects in Alabama and other southeastern states.

The plant will consist of four units, of 100,000-hp. or 76,400-kw. capacity

each, to occupy a site of 100 acres, and construction is expected to begin as soon as materials and machinery may be assembled. The first unit will be built in conformity with plans to permit the addition of the remaining three units as soon as their use is justified by commercial demands. Specifications for machinery and materials have been sent to various factories, it is announced, so that actual construction may begin within a few months. The new plant will be equipped with a single steam turbo-generator and will have two large boilers to deliver steam at a pressure of 450 lb. per sq.in. The boilers will be capable of delivering steam at this pressure and at a temperature of 725 degrees at a rate of 450,000 pounds per hour. An official estimate of the cost of the plant has not been disclosed, but it is certain the expenditure will be several millions of dollars.

American Technical Museum to Be Started Soon

Construction of a great technical museum in Chicago will be started as soon as contracts can be let, a recent report states. Though technical museums have been established in Europe for many years, this type of permanent exhibition of natural science and engineering projects is new to the United States.

Waldemar Kaempffert, executive director of the new Chicago museum, has spent the last four months in Europe studying museum practice. He plans to pattern America's first technical museum after the one in Munich where Oscar von Miller has made machines live. The originals or reproductions of all epoch-making inventions will be exhibited in surroundings that give proof of the development which followed in their wake. Many types of steam and gasoline engines will be shown. Visitors will be able to push buttons, pull levers and themselves set many of the exhibits in motion. A $5,000,000 edifice will house the displays.

District Heating School At Purdue University

The National District Heating Association will offer a valuable course of study in district heating at Purdue University, Lafayette, Indiana, May 20 to 24, inclusive. Only one course will be given this year, being similar to Course II of last year. Applicants should have a grade school or high school training, but need not be college graduates. Membership in the N.D.H.A. is not required. In 1928 some sixty men attended this school.

Lectures will be given by the University professors and men from the district heating companies. The lectures will be supplemented by slides and motion pictures of processes and appliances. Among the subjects included will be: accessory apparatus for district heating; principles governing the flow of fluids; new methods of steam heating; the flow of steam in pipes; heating losses from the distribution system and their prevention; welding; methods of estimating steam consumption and maximum demand.

A charge of ten dollars for the week's tuition will be made by the University. Requests for detailed information regarding the course should be addressed to Prof. C. H. B. Hotchkiss, Purdue University, Lafayette, Indiana.

Coming Conventions

American Boiler Manufacturers Association. Annual meeting, June 3-5, Sky Top Lodge, Cresco, Pa. A. C. Baker, secretary, 801 Rockefeller Blvd., Cleveland, O.

American Institute of Electrical Engineers, annual summer convention, Swampscott, Mass., June 24-28. Pacific Coast Regional Meeting, Santa Monica, Calif. Sept. 3-6. F. L. Hutchinson, secretary, 33 West 39th St., New York City.

American Institute of Refrigeration, at Washington, May 2, 3, 1929. Louis Baron, secretary, 203 West 13th St., New York City.

American Oil Burner Association, annual convention, Hotel Pennsylvania, New York City, April 9-11, 1929. For information, address the headquarters of the Association at 420 Madison Ave., New York City.

American Society of Heating and Ventilating Engineers, annual summer meeting, Big Wind Inn, Lake of Bays, Ontario, Can., June 27-29. A. V. Hutchinson, secretary, 29 W. 39th St., New York City.

American Society of Mechanical Engineers, spring meeting, Salt Lake City, Utah, July 1-4, 1929. Rochester regional spring meeting, Rochester, N. Y., week of May 13. Calvin Rice, secretary, 29 West 39th St., New York City.

American Welding Society, annual meeting to be held in New York City, April 24-26. Secretary M. M. Kelly, society headquarters, 33 West 39th St., New York City.

Association of Iron and Steel Electrical Engineers, 25th annual convention, Pittsburgh, Pa., June 17-22, 1929. A. A. Stewart, secretary, Pittsburgh Steel Co., Monnessen, Pa.

Canadian Electrical Association, annual convention, to be held June 19-21, at St. Andrews-by-the-Sea, N. B. H. M. Lyster, secretary, Power Building, Montreal, Que.

Master Boiler Makers Association, at Atlanta, Ga., May 21-24. H. D. Vought, secretary, 26 Cortlandt St., New York City.

National Association of Power Engineers, 47th annual convention, Chattanooga, Tenn., Sept. 9-13. Fred Raven, secretary, 417 South Dearborn St., Chicago, Ill.

National Electric Light Association. Annual meeting at Atlantic City, N. J., June 3-7. A. J. Marshall, secretary, 420 Lexington Ave., New York City.

National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York City, Dec. 2-7. Charles F. Roth, manager, Grand Central Palace, New York City.

National Oil and Gas Power Meeting. Under auspices of A.S.M.E. Oil and Gas Power Division and the Pennsylvania State College. June 24-27, State College, Pa. F. G. Hechler, chairman, State College, Pa.

World Engineering Conference, Tokyo, Japan, October, 1929. All correspondence should be addressed to the Secretary, World Engineering Conference, Nikon, Kogyo Club, Morunouchi, Tokyo.

Double-Winding Generator Brings Coffin Award

D. D. Chase, T. F. Barton and A. R. Smith, engineers of the General Electric Company of Schenectady, N. Y., have received awards under the Charles A. Coffin Foundation for their part in the development of the 165,000-kw. double-winding generator now being installed at the East River station of the New York Edison Company. The announcement, recently made by the General Electric Company, follows the annual practice of the company in making Coffin awards to employees who make exceptional contributions in the engineering and other company departments.

Welding School Expands Facilities

To meet the rapidly increasing demand for practical instruction in arc welding, the Welding School maintained by the Lincoln Electric Company is greatly expanding its facilities. No tuition is charged at the Lincoln School, and any ambitious mechanic is free to take the course up to the capacity of the school.

The course is of six weeks' duration and is intensely practical in character. Students are required to conform to shop rules and must keep the conventional shop hours. The progress of an individual student is limtied only by his own aptitude and application, since individual rather than class instruction is given.

It frequently happens that experienced arc welders will spend from a week to ten days in a sort of extra curricula course to learn special work, where they feel their experience to be insufficient for a contemplated project.

The Lincoln Welding School is under the direct supervision of Arthur E. Madson.

S. F. Electrical Development League Installs Officers

Following its annual election, the San Francisco Electrical Development League has entered upon the work of its new year under the guidance of its new president, Don C. Ray, assistant to the vice-president, Pacific Gas and Electric Company, in charge of public relations and sales. R. N. Phelan, secretary-treasurer, McGraw-Hill Company of California, was re-elected secretary-treasurer of the league. Directors elected to serve for two years include Guy A. Barker, Johns-Manville Corporation; Allyn G. Smith, Pacific Telephone & Telegraph Company; and Robert A. Hudson, Hunter & Hudson, consulting engineers. The directors who still have one year to serve are Lloyd Flatland, Globe Electric Works; Ernest Ingold, Ernest Ingold, Inc.; and Benjamin M. Tassie, Manning Bowman & Company.

A mock inaugural ceremony was one of the features of the installation program.

N.A.P.E. Announces New England Convention

The annual convention of the New England States Association of the National Association of Power Engineers has been announced for June 20 and 21. It will be held this year at Fitchburg, Mass. In connection with the convention the annual exhibition of power plant machinery and supplies will be held on the same dates, in the state armory in Fitchburg. George D. Hassett, 563 Water St., Fitchburg, as secretary of the New England association, is receiving applications for space at the exhibition.

Many events and features of interest are planned for the benefit and entertainment of the delegates and visitors to the convention, including a special entertainment on Friday evening, June 21, and an outing on the following day.

OBITUARY

EDWIN S. HALLETT, chief engineer of the St. Louis Board of Education, died at the age of 66 of pneumonia on March 26 at his home, 5156 Cabanne Avenue. He was the originator of the ozone ventilating system now used in many St. Louis schools and started the school for training building custodians in the operation of heating and ventilating systems.

Born in Borden, Ind., Mr. Hallett started his career as a school teacher and later became superintendent of schools at Corydon, Ind. He went to St. Louis in 1908 and took up the duties of chief engineer for Federal buildings. In this position, he superintended the construction of many government buildings in the Middle West and Southwest. He joined the Board of Education's organization and later became chief engineer.

A frequent contributer to various engineering magazines, Mr. Hallett was an associate editor of *Domestic Engineering Magazine*. He was a member of the American Sociery of Heating and Ventilating Engineers, the St. Louis Electrical Board of Trade and a past member of the American Society of Mechanical Engineers.

PERSONALS

A. C. KNIGHT has been added to the selling staff of the New York Office of the Reading Iron Company.

P. F. CASSIDY, chief engineer of the industrial oils section of the sales engineering department of the Tide Water Oil Company, has just returned from a two-months tour of Cuba in the interest of his company.

DR. D. S. JACOBUS, advisory engineer of the Babcock & Wilcox Company, has been recuperating in Florida from the results of an operation. His many friends will be glad to learn that he is recovering rapidly.

With the Society Sections

A. S. M. E., Metropolitan Section. Meeting April 11, Fuels Division, Subject: "The Heat Balance as a Means of Determining Evaporating Efficiencies of Steam Generating Equipment," by B. J. Cross, Combustion Engineering Corp. Meeting April 19, Division of Applied Mechanics, Subject: "Crankless Reciprocating Engines and Pumps," by A. G. M. Michell, Michell-Crankless Engine Corp. Meeting April 24, Oil and Gas Power Division, Subjest: "Diesel Power Plants for Large Buildings," by Edgar J. Kates, Consulting Engineer. Meeting April 29, Power Division, Subject: "The Modern Marine Power Plant," by W. Flanders and P. Lamb.

A. S. M. E., Detroit Section. Meeting April 19, at Ann Arbor, Mich. Presentation of Life Membership to Dean M. E. Cooley by Alex Dow, President, Detroit Edison Company, Detroit, Mich.

A. S. M. E., Philadelphia Section. Meeting, April 23. Subjects: "Petroleum and Oil—The use of centrifugal pumps for hot and cold oil and other liquids at various pressure up to 1,400 lb. per sq.in.," by W. R. Layne, Chief Engineer, Byron-Jackson Pump Manufacturing Company, Dallas, Texas; "Diesel Engine," by Julius Kuttner, Editor, Oil Engine Power, New York, N. Y.

A. S. M. E., Worcester Section. Meeting, April 11. Subject: "Lubrication," by Prof. W. K. Lewis, Massachusetts Institute of Technology, Cambridge, Mass.

American Society Heating and Ventilating Engineers, Philadelphia Chapter. Meeting, April 11. Subject: "Problems in Connection with the Conditioning of the U. S. Capitol at Washington," by J. I. Lyle, Treasurer and General Manager, Carrier Engineering Corporation, Newark, N. J.

American Water Works Association, Florida Section. Meeting, April 10, at Jacksonville, Fla. Subject to be announced later.

Engineers Club of St. Louis. Meeting April 10. Subject: "Pumps and Pumping," by A. T. Hunter, De Laval Steam Turbine Company.

New England Water Works Association. Special meeting, April 10, at Waterbury, Conn. Papers on large and small meters will be given.

Plant Engineers' Club of Boston. Meeting, April 17, at South Walpole, Mass. Subject: "The Use of High Boiler Pressure in an Industrial Plant," by Mr. Conrad, Plant Engineer, Bird & Sons, Inc., South Walpole, Mass.

The Newcomen Society. Fifth American meeting, April 24. Unveiling of tablet on grave of Josiah Hornblower, Belleville, N. J., at 4:30 p.m. Dinner and meeting, Engineers' Club, at 7:00 p.m. Subjects; "First Steam Engine in America," by L. F. Loree; "Evolution of the Typewriter," by John H. Barr.

Northwest Electric Light and Power Association. 22nd Annual Convention, June 26-29, 1929, at Seattle, Wash. Registration and information: J. J. Hayes, Westinghouse Electric & Manufacturing Company, Seattle, Wash.

H. W. ARMSTRONG, at the meeting of the Board of Directors of the Joseph Dixon Crucible Company, was appointed to succeed the late William Koester, as treasurer of the company.

BUSINESS NOTES

THE C. & G. COOPER COMPANY, Mt. Vernon, Ohio, announces a consolidation with The Bessemer Gas Engine Company, Grove City, Pa. The new company is known as The Cooper-Bessemer Corporation with E. J. Fithian, chairman of the board and B. B. Williams, president and general manager. The combination now offers a complete line of gas or diesel engines and compressors ranging from 30 to 1,500 hp.

ALEXANDER BROTHERS, INCORPORATED, on May 1st, will remove its Chicago branch to 162-166 N. Clinton Street, Chicago.

DWIGHT P. ROBINSON, president, United Engineers & Constructors, Inc., Philadelphia, Pa., announces the formation of United Engineers & Construc-

FUEL PRICES

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard	New York	$2.35@$2.40
Kanawha	Columbus	1.25@1.06
Smokeless	Cincinnati	2.15@ 2.25
Smokeless	Chicago	1.75@ 2.25
S. E. Kentucky	Chicago	1.35@ 1.60
Steam	Pittsburgh	1.55@ 1.75
Gas Slack	Pittsburgh	1.00@ 1.15
Big Seam	Birmingham	1.25@ 1.50
Anthracite (Gross Tons)		
Buckwheat	New York	$2.75
Barley	New York	1.50

FUEL OIL

New York—Apr. 4, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4.75c. per gal.; 36@40 deg., furnace, tank-car lots, 6.25c. per gal.

St. Louis—Apr. 1, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.3959 per bbl. or 42 gal.; 26@28 deg., $1.4459 per bbl.; 28@30 deg., $1.4959 per bbl.; 30@32 deg., $1.5459 per bbl.; 32@36 deg., gas oil, 4.776c. per gal.; 38@40 deg., distillate, 5.73c.

Pittsburgh—Mar. 19, f.o.b. local refinery, 30@34 deg., fuel oil, 5c. per gal.; 36@40 deg., 5.25c. per gal.

Philadelphia—Mar. 21, 13@19 deg., $1.05@$1.10 per bbl. or 42 gal.; 22 deg. plus, $1.47@$1.53 per bbl.; 23@27 deg., $2.10@$2.16 per bbl.

Cincinnati—Apr. 2, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5.5c. per gal.; 30@32 deg., 5.95c. per gal.

Chicago—Mar. 30, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 65c. per bbl.; 26@30 deg., 75c. per bbl.; 30@32 deg., $1.20 per bbl.

Boston—Apr. 1, tank-car lots, f.o.b. 12@14 deg Baumé, 4.54c. per gal.; 28@32 deg., 5.62c. per gal.

Dallas—Mar. 30, f.o.b. local refinery, 26@30 deg., $1.25 per bbl. or 42 gallons.

tors (Canada) Ltd., Drummond Building, Montreal, Canada, with R. M. Henderson as managing director.

DAYTON-DOWD COMPANY has appointed the Corken Pump & Machinery Company of Oklahoma City and Tulsa, as its district representatives.

THE HAHN ENGINEERING COMPANY has become a division of the Lancaster Iron Works Incorporated, and has moved its main office to the main office of the latter, at Lancaster, Pa.

THE BROWN INSTRUMENT COMPANY, announces two new appointments; that of C. H. Kerr as vice-president and general manager, and that of G. W. Keller as vice-president and general sales manager.

SQUARE D COMPANY is the name under which the consolidation of the manufacturing financial and engineering resources of the former Square D Company of Detroit, Michigan and Peru, Indiana, and of the Industrial Controller Company of Milwaukee, Wis. have been united.

TRADE CATALOGS

THE HARDINGE COMPANY has moved from 120 Broadway to the Chanin Building, 122 East 42nd Street, New York City.

THE VULCAN SOOT CLEANER COMPANY has opened a New York office at 120 Liberty Street under the direction of F. W. Linaker, assisted by C. H. Baker.

ROTARY PUMPS.—Catalog No. 54, showing the complete line of Trahern Rotary Gear Pumps, for hand and power use, is published by the George D. Roper Corporation, Rockford, Ill., who is the manufacturer. It is divided by colored pages, according to the application, and each section is illustrated by charts and photographs.

GENERATORS, MOTORS AND EXCITERS —Two leaflets, numbers 1075 and 432A, are offered by the General Electric Company, Schenectady. The first describes and illustrates temperature-indicating equipments for alternating-current generators and motors and the second treats of direct-current generators and exciters, Type CD.

BAKELITE—A few new uses of Bakelite are pictured and briefly described in a folder put out by the Bakelite Corporation, 247 Park Avenue, New York City.

FIRE PUMPS—A Bulletin No. 104, having twelve pages, blueprints, illustrations and some printed matter, on fire pumps, has been issued by the Chicago Pump Company of Wolfram Street, Chicago, Illinois. These pumps have been approved by fire underwriters, insurance companies, and fire prevention bureaus.

GRATING—William F. Klemp Company, 6624 S. Melvina Ave., Chicago, devotes a new 16-page catalog to different types of "Diamond" grating, featuring the construction, typical installations and the various types of anchors used with the grating.

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Calif., Los Angeles—Adohr Creamery Co., 1801 La Cienega Rd., is receiving bids for the construction of a 96 x 107 ft. power plant. Morgan, Walls & Clements, Van Nuys Bldg., are architects.

Calif., Los Angeles—Kaspare Cohn Hospital Association, 3942 Whittier Blvd., awarded contract for an 8 story hospital on Fountain Ave., to Baruch Corp., Lincoln Bldg. Estimated cost $1,000,000. Steam heating and ventilation systems, etc., will be installed.

Calif., Los Angeles—Southern California Telephone Co. is having plans prepared for a 12 story telephone building including steam heating system, elevators, etc., at 740 South Olive St. Estimated cost $1,500,000. J. and D. B. Parkinsons, 808 Title Insurance Bldg., are architects.

Calif., Los Angeles—Union Ice Co., 1315 East 7th St., awarded contract for the construction of an ice plant on Industrial St., to Richards-Neustadt Construction Co., 117 West 9th St., also plans a cold storage plant at Chester Ave. and Laurel St., Santa Cruz. Estimated cost $40,000. Private plans.

Calif., Sacramento—State Harbor Commission, San Francisco, plans to vote $10,000,000 for extensions and improvements to harbor facilities to include cold storage terminal at Mission Rock in San Francisco Bay here. F. G. White, State Harbor Commission, Ferry Bldg., San Francisco, is engineer.

Ga., Blue Ridge—Toccoa Electric Power Co., subsidiary of Tennessee Electric Power Co., 540 Market St., Chattanooga, Tenn., awarded contract for completing work on 20,000 hp. hydro electric plant and dam 165 ft. high on the Toccoa River near here to Stevens & Wood, 20 Pine St., New York, N. Y. Estimated cost $4,500,000.

Ill., Chicago—Holabird & Root, 333 North Michigan Ave., Archts., will receive bids until Apr. 16, for addition to frequency changer house at Fisk and 22nd Sts. for Commonwealth Edison Co., 72 West Adams St. Estimated cost $300,000.

Ill., Chicago — P. F. Reynolds, 38 South Dearborn St., will soon receive bids for the construction of a 16 story apartment and stores building including mechanical refrigeration system, elevators, etc. at Clark St. and Lincoln Park W. Estimated cost $2,500,000. McNally & Quinn, 10 South La Salle St., are architects.

Ill., Chicago—Syndicate, c/o G. Gannon, 127 North Dearborn St., is having plans prepared for the construction of a 5 story hospital as first unit of large development at 1111 North La Salle St. Estimated cost $700,000. Total cost $6,000,000. L. Guenzel, 879 North State St., is architect.

Ill., East St. Louis—East Side Levee & Sanitary Dist., 213 Metropolitan Bldg., awarded contract for the construction of two pumping stations, including four 54 in. and two 36 in. screw pumps to H. H. Hall Construction Co., Murphy Bldg. Estimated cost $402,000.

Ind., Fort Wayne—Lincoln Bank & Trust Co. will receive bids until Apr. 10 for a 22 story bank and office building, including steam heating and ventilation systems, elevators, etc., at Court and Barry Sts. Estimated cost $1,000,000. A. M. Strauss, 415 Cal-Wayne Bldg., is architect.

Mass., Attleboro — Attleboro Steam & Electric Co., E. Tregroning, Mgr., 24 South Main St., is having plans prepared for the construction of a power house on West St. Estimated cost $100,000. O. M. Higgins, Park St., is architect.

Mass., Attleboro — City, F. E. Briggs, Mayor, is having plans prepared for the construction of a pump house, wells, etc. J. J. Van Valkenburgh, Framingham, is engineer.

Mass., Attleboro—W. R. Ross, 157 East Ave., Pawtucket, R. I., awarded contract for the construction of an ice plant on Bacon St. here to E. Bousher, 10 Warwick Rd., Pawtucket, R. I.

Mass., Bridgewater — Bd. of Education, State House, awarded contract for the construction of a power plant at State Normal school to F. Losardo, 35 George St., Hyde Park. Estimated cost to exceed $40,000.

Mass., East Boston (Boston P. O.)—City will soon award contract for the construction of a pumping station in connection with sewage system. T. F. Bowes, City Hall, is engineer.

Mass., Lowell—Daniel Gage Ice Co. Inc., D. L. Lyons, Pres., is receiving bids for the construction of an artificial ice plant on Pawtucket St. Estimated cost $60,000. R. Palmer, 58 Suffolk St., Holyoke, is architect.

Mass., Weymouth—Edison Electric Illuminating Co., 39 Boylston St., Boston, will build a transmitting station. Work will be done by day labor.

Mass., Woburn — Edison Electric Illuminating Co., 39 Boylston St., Boston, is having preliminary plans prepared for the construction of an electric sub-station here. Estimated cost $500,000. Bigelow, Wadsworth, Hubbard & Smith, 11 Beacon St., Boston, are architects.

Mont., Great Falls — Columbus Hospital, Sisters of Charity, is having plans prepared for a 6 story hospital, including steam heating system, elevators, etc. Estimated cost $1,000,000. Shanley & Baker, First National Bank Bldg., are architects.

Mo., St. Louis—Excelsior Leader Laundry Co., 2323 Texas Ave., awarded contract for the construction of a boiler house to Fruin-Colnon Contracting Co., Merchants-Laclede Bldg. Estimated cost $75,000.

Mo., St. Louis — Liquid Carbonic Co., South Kedzie St., Chicago, Ill., awarded contract for the construction of an ice plant here to H. K. Ferguson Co., Hanna Bldg., Cleveland. Estimated cost $200,000.

Mo., St. Louis — St. Louis-San Francisco R.R., Frisco Bldg., will build a 50 x 110 ft. engine house at 7049 Fyler Ave. F. G. Jonah, is chief engineer. Work will be done by owners forces.

N. J., Asbury Park — Syndicate, c/o Dwight P. Robinson Co., Inc., 125 East 46th St., New York, N. Y., Contrs., contract awarded for a hotel at Kingsley St. and Deal Lake Dr. Estimated cost $1,000,000. Steam heating system, etc., will be installed.

N. J., Elizabeth — Dry Ice Corp., 1001 Newark Ave., awarded contract for addition to ice plant to H. K. Ferguson Co., Hanna Bldg., Cleveland, O. Estimated cost $50,000.

N. J., Elizabeth — Elizabethtown Water Co., 64 Broad St., will soon award contract for the construction of a pumping station, etc. Estimated cost $25,000. Private plans.

N. J., Jersey City — Calvary Lutheran Church, G. E. Hagen, 921 Summit Ave., is

having plans prepared for the construction of a 10 story apartment and church, including steam heating ventilation and refrigeration systems, boilers, elevators, etc., at Boulevard and Highland Ave. Estimated cost $750,000. C. Shlowitz, 26 Journal Sq., is architect.

N. J., Perth Amboy—Public Service Electric & Gas Co., 80 Park Pl., Newark, awarded contract for the construction of an electric sub-station at Mechanic and Pearl Sts. to Public Service Production Co., 80 Park Pl., Newark. Estimated cost $40,000.

N. J., Princeton—Princeton Improvement Inc., c/o A. J. Thomas, 2 West 46th St., New York, N. Y., is having sketches made for an apartment development including steam heating system, etc., at Nassau St. Estimated cost $1,000,000.

N. Y., Albany—Bd. of Supervisors, Court House, awarded contracts for the construction of a group of buildings in connection with Ann Lee Home to M. Kantrowitz, 20½ Market St., $129,000, also remodeling power house, to Stearns Electric Construction Corp., 108 Hamilton St., $43,000.

N. Y., Brooklyn — Dept. of Mental Hygiene, Capitol, Albany, awarded contract for remodeling power house and pump room at Brooklyn State Hospital, here, to J. E. Lee, 3103 Farragut Rd., Brooklyn. Estimated cost $31,104.

N. Y., Long Island City—S. Parisi, 1616 Hendrickson St., Brooklyn, plans the construction of an ice manufacturing plant at 111 Northern Blvd. Estimated cost $60,000. Burke & Olsen, 32 Court St., Brooklyn, are architects.

N. Y., Rochester — Dept. of Ways & Means, Albany, appropriated $850,000 for the construction of a power house at Rochester State Hospital, here.

N. Y., Rochester—Rochester Packing Co., F. Tobin, Pres., 900 Maple St., is receiving bids for the construction of three cold storage plants, also 41 x 50 ft. boiler house.

N. D., Grafton—City plans an election soon to vote $40,000 bonds for the construction of a power plant.

O., Cleveland — John Carroll University, B. J. Rodmen, Pres., West 30th St. and Carroll Ave., is having preliminary plans prepared for the construction of a group of college buildings including power plant, etc. Total estimated cost $2,500,000.

O., Cleveland—Cleveland Union Terminal Co., C. L. Bradley, Pres., Terminal Tower, is having plans prepared for an 18 story office building including steam heating system, etc. at West 2nd St. and Prospect Ave. Estimated cost $2,000,000. Graham, Anderson, Probst & White, Railway Exchange Bldg., Chicago, Ill., are architects.

O., Madison—Village plans the construction of a pumping station, etc. in connection with waterworks. P. Cook, Court House, Painesville, is city engineer. R. F. McDowell, Chester-12th Bldg., Cleveland is consulting engineer.

Okla., Wagoner — City plans an election soon to vote $76,500 bonds for waterworks improvements including new filter plant, pumping equipment, mains, etc. E. W. Gantt Co., 1116 West Moise St., Oklahoma City, is engineer.

Pa., Philadelphia—Lewis Jones Inc., 64th and Lebanon Sts., will build a 2 story addition to boiler house. Estimated cost $10,000. Private plans.

Tex., Barreda — Cameron County Water Improvement Dist. 8, c/o C. P. Barreda, Brownsville, plans an election to vote $1,000,000 for the construction of an irrigation project to include pump house, pumps, engines, etc. Private plans.

Tex., El Paso—Texas-Louisiana Power Co. will build a 40 ton ice plant. Estimated cost $60,000. Private plans. Work will be done by day labor.

Tex., Floresville — San Antonio Public Service Co. and South Texas Ice Co., c/o W. Smith, will build a 20 ton ice plant here. Estimated cost $35,000. A. B. and R. M. Ayres, 626 Bedell Bldg., San Antonio, are architects. Work will be done by day labor.

Tex., Lozano—Lozano Cold Storage Ice & Power Co., c/o K. Brown, Harlingen, plans the construction of an ice and power plant. Estimated cost $60,000. Work will be done by day labor.

Tex., San Antonio — J. J. Nix, Travis Bldg., awarded contract for the construction of an 18 story office building, hospital and garage at Navarro and Crockett Sts., to J. Haynes, Moore Bldg. Estimated cost $1,250,000. Steam heating, ventilation and refrigeration systems, boilers, pumps, elevators, etc., will be installed.

Tex., Waxahachie — Pure Ice Co., c/o W. B. Bender, awarded contract for the construction of a 25 ton ice plant to O. B. Bennett, Waxahchie. Estimated cost $36,000.

Tex., Whitewright — Southern Ice & Utilities Co., Dallas, plans the construction of a 20 ton cold storage and refrigeration plant here. Private plans.

Wash., Walla Walla — Pacific Power & Light Co., G. W. Talbot, Pres., Gasco Bldg., Portland, Ore., plans an outdoor addition to sub-station to house a 3,000 kva. outdoor transformer together with switching equipment, etc. here.

Ont., London — Public Utilities Commission, City Hall, plans the construction of a new sub-station, etc. in connection with proposed electrical system. Estimated cost $70,000. Work will be done by day labor.

Ont., Ottawa — Hydro-Electric Power Commission, 190 University Ave., plans the following expenditures in connection with system; new transformer station, 110 kw. capacity at Smith's Falls, $80,450; new transformer station at Ottawa, $200,000; new transmission line at Prescot line and St. Lawrence system lines. $568,950. Also development of water power on Musquash River between Lake Muskoka and Georgian Bay. five sites are involved with an output of 49,000 hp. Plans include dams, power house, turbines, generators, switches, transformers, etc. Estimated total cost $5,775,000. First site to be developed will be at Ragged Rapids, 12,000 hp., $1,300,000.

Ont., Toronto—L. Coldoff & Co., 313 Grace St., plans the construction of a 16 story loft and office building including steam heating system, elevators, etc. at York and Piper Sts. Estimated cost $1,000,000. Kaplan & Sprachman, 305 Dundas St. W., are architects.

Ont., Toronto — Bell Telephone Co. of Canada, 256 Notre Dame St. W., Montreal, Que., plans the construction of a 12 story automatic telephone exchange building, including steam heating system, electric elevators, etc., on Temperance St. Estimated cost $1,500,000. J. McNab, 256 Notre Dame St. W., Montreal, Que., is archtiect.

Equipment Wanted

Engine — City of Minden, Neb., B. O. Aabel, Clk., will receive bids until Apr. 15, for a 300 to 360 hp. Diesel oil engine connected to a 225 to 250 kw. generator and exciter for proposed waterworks. Est. cost $35,000.

Pump — Northeast Tacoma District, Tacoma, Wash., is receiving bids for the installation of a booster pump for proposed waterworks system. Estimated cost $31,950.

Pumping Unit — Bd. of Commissioner, City Hall, Newark, N. J., is having preliminary plans prepared for the installation of a steam-driven pumping unit at Newark Bay pumping station.

Pumping Equipment — City of St. Clair, Mo., will soon receive bids for pumping equipment, etc. for proposed waterworks improvements. Estimated cost $19,500.

Pumps—City of Olustee, Okla., plans to purchase vertical turbine pumps for proposed waterworks improvements. Estimated cost $24,000.

Pumps—City of Sierra Madre, Calif., new deep well and booster pumps for well No. 1, for proposed waterworks improvements.

Pumps, etc.—City of Newton, Kan., will receive bids about May 15, for pumps, etc. for proposed sewage disposal plant. Estimated cost $69,000.

Pumps, Motors, etc.—I. K. Welborn, Clk., Paso Robles, Calif., will receive bids until Apr. 15, for a 3 stage Byron Jackson high capacity deep well turbine pump, one 75 hp., 3 ph., 1,750 r.p.m. 440 v., 60 cycle automatic starting, G. E. type motor, automatic starter, etc. for proposed waterworks improvements.

Transformers and Meters—E. B. Merritt, City Clk., Anaheim, Calif., will receive bids until Apr. 11, for furnishing city for one year with electric transformers and electric meters.

Turbines, Generators, Transformers, etc. —Bd. of Contracts & Awards, J. G. Newbegin, Mayor, Tacoma, Wash., will receive bids until Apr. 18, for the installation of one or two 37,500 hp. hydraulic turbines, one or two 30,000 kva. electric generators, four or six 20,000 kva., three or six 14,000 kva. three 6,667 kva., one 333 kva. transformers, and one 15,000 kva. synchronous condenser in unit No. 2 of Cushman Power Project. Estimated cost $3,000,000.

Industrial Projects

Calif., Torrance — CEMENT PLANT — Hercules Portland Cement Co., 4th and Washington Sts., will soon receive bids for an 8 story cement plant including machine shop, packing plant, grinding mill, crushing plant, etc. Estimated cost $2,500,000.

Conn., Hartford—SERVICE BUILDING —Hartford Electric Light Co., S. Ferguson, Pres., awarded contract for a 4 story, 160 x 180 ft. electric service building on Sheldon St. to Industrial Construction Co., 721 Main St. Estimated cost $400,000.

Ind., Indiana Harbor (mail East Chicago) —BAR MILL, etc.—Inland Steel Co., 38 South Dearborn St., Chicago, Ill., plans the construction of a bar mill, jobbing mill and office, here.

Md., Baltimore—AIRPLANE FACTORY —G. L. Martin Co., 16800 St. Clair St., Cleveland, O., is receiving bids for a 1 story, 300 x 932 ft. factory here. Estimated cost $1,000,000. P. Lindsley Small & Associates, Terminal Tower, are architects.

Mich., Bridgman — FOUNDRY and HEATING PLANT — Mathieu & Sons Foundry Co., had plans prepared for a 1 story, 60 x 240 ft. foundry to include heating plant, etc. Estimated cost $70,000. W. Fett, South Bend, Ind., Engr.

Mich., Detroit — AUTOMOBILE ASSEMBLY PLANT — Cadillac Motor Car Co., Clark Ave., plans the construction of a 1 story automobile assembly plant on Clark Ave. Estimated cost $250,000. Architect not announced. Electric motors and assembly line equipment will be required.

Mich., Detroit—PRINTING PLANT—G. D. Mason Co., 409 Griswold St., Archt., will receive bids about Apr. 15 for a 5 story, 80 x 200 ft. printing plant on East Jefferson Ave. for Detroit Press Co., 5940 Cass Ave. Estimated cost $200,000. Electric motors, etc., will be required.

Mich., Detroit — DIE SHOP — Richard Bros Die Works, 4646 Lawton Ave., awarded contract for a 1 story, 95 x 205 ft. die shop to The Austin Co., General Motors Bldg. Estimated cost $90,000. Electric motors and 10 and 15 ton traveling bridge cranes will be required.

Mo., St. Louis—ROPE FACTORY ADDITION—Broderick & Bascom Rope Co., 4233 North Union Blvd., awarded contract for a 1 and 2 story, 142 x 218 and 130 x 162 ft. addition to factory at Union Blvd. and Brown Ave. to Wimmer Contracting Co., Victoria Bldg. Estimated cost $150,000.

O., Canton — BEARING FACTORY — Timken Roller Bearing Co., Dueber Ave., S. W., plans the construction of a 380 x 520 ft. factory. Estimated cost $500,000. Private plans.

O., Dayton—FACTORY—National Cash Register Co., Main and K. Sts., awarded contract for a 6 story factory to H. R. Blagg Co., 1229 East 3rd St. Estimated cost $800,000.

Pa., Philadelphia — MEAT PACKING PLANT—F. G. Vogt & Sons, 30th and Race Sts., will receive bids in May for the construction of a meat packing plant. Estimated cost $1,000,000. C. B. Comstock, 110 West 40th St., New York, N. Y., is architect.

Tenn., Old Hickory — WRAPPING PAPER FACTORY — DuPont Cellaphane Co., subsidiary of E. I. DuPont de Nemours & Co., Abbott Rd. and Orchard Park, Buffalo, N. Y., will build a wrapping paper factory here. Estimated cost $2,000,000 to $3,000,000. Work will be done by day labor.

Wash., Everett — PULP and PAPER MILL — Puget Sound Pulp & Timber Co., Seattle, plans the construction of a pulp and paper mill here. Estimated cost $3,000,000.

W. Va., South Charleston—CHLORINE PRODUCTS FACTORY — Westvaco Chlorine Products Inc., awarded contract for addition to factory to H. K. Ferguson Co., Hanna Bldg., Cleveland. Estimated cost $1,225,000.

Ontario—REFRIGERATOR SYSTEMS—Refrigerating Equipment Ltd., C. W. Stillman, Mgr., Ontario St., Stratford, has secured Canadian rights for the manufacture of refrigerator systems of DriKold Co., Cincinnati, O., and plans to equip plant, here. Estimated cost $100,000.

Ont., Walkerville—AUTOMOBILE FACTORY—Chrysler Corp., plans the construction of a second unit of automobile plant, 1 and 2 story. Estimated cost $1,500,000. Hutton & Souter, 6 Hughson St. S., Hamilton, are architects.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

ADVANCES predominated strongly in March price changes in electrical supplies. These increases affected armored cable, flexible cord, non-refillable fuses, fuse plugs, rubber-covered copper wire and soldering paste. Among the power-plant supplies, there were price advances in babbitt metal, rivets and white lead. Wrought-iron pipe makers advanced discounts to jobbers, April 1, in an effort to stabilize the market and also to strengthen relationship between the manufacturers and the resale organizations. The declines in materials listed, occurred in Mazda lamps, 50 and 60 watts, less than standard package quantities, and in linseed oil.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		(net) 60c. per ft.
Common, 2½-in., cotton, rubber-lined	80c. per ft. list, less	50%

Air—Best grade

¾-in., per ft.	3-ply	$0.30	4 ply	$0.36

Steam—Discounts from List

First grade	40%	Second grade	45%	Third grade	50–10%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	60%

LEATHER BELTING—List price, 24c. per lin.ft., per inch of width, for single ply, at New York warehouses:

Grade	Discount from list
Medium	30–10%
Heavy	30– 5%

RAWHIDE LACING—For cut, best grade, 30–5%; 2nd grade, 45–5%. For laces in sides, best, 57c. per sq.ft.; 2nd, 52c., net. Semi-tanned, cut, 30–5%.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ¾ in.	$0.90
Asbestos for high-pressure steam, ¾ in.	1.75
Duck and rubber for piston packing	.90
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.85
Wire insertion asbestos sheet	1.20
Rubber sheet	.45
Rubber sheet, wire insertion	.75
Rubber sheet, duck insertion	.55
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia, high pressure		50%
Asbestos, air cell, for low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.25 per bbl., without bags, delivered by truck to site of job. Bag charge, 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, beams and channels, 3 to 15-in.; angles, 3 to 6-in., ¼-in. thick; tees, 3-in. and larger; and plates, ¼-in. thick and heavier; all $3.30 per 100 lb. in lots up to 3,999 lb.

COTTON WASTE—The following prices are in cents per lb., at warehouse:

	New York	Cleveland	Chicago
White	10.00@13.50	16.00	15.00
Colored	9.00@13.00	12.00	12.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed white wipers, as follows:

Chicago (100 lb. bales)	$0.16
New York (100 lb. bales)	16
Cleveland (per thousand)	38.00

LINSEED OIL—These prices are for raw oil in barrels, f.o.b., in 1 to 4 bbl. lots:

	New York	Cleveland	Chicago
Per pound	$0.109	$0.11	$0.113

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b., New York:

	Dry	In Oil
Red	$13.75	$15.25
White	13.75	13.75

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Tank rivets, ⅞-in. diameter and smaller, list (Apr. 1, 1927) less 60% in full packages, for immediate delivery from warehouse stocks in New York and vicinity.

Structural rivets, round head, per 100 lb.:

New York	$4.50*
Chicago	3.60
Pittsburgh mill	3.10

*Price is for full packages; broken package lots, $6.00 net, delivered.

REFRACTORIES—Prices in car-loads, f.o.b., plant:

Chrome brick, eastern shipping points	per net ton	$45.00
Chrome cement, 40@50% Cr_2O_3, in bulk	per net ton	22@25
Chrome cement, 40@50% Cr_2O_3, in sacks	per net ton	26@29
Magnesite brick, 9-in. straights	per net ton	65.00
Magnesite brick, 9-in. arches, wedges and keys	per net ton	71.50
Magnesite brick, soaps and splits	per net ton	91.00
Silica brick, Mt. Union, Pa.	per M	43.00
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	43@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Maryland	per M	35@38
Chrome ore crude, 40@50%	per net ton	18.00@22.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	70.00
Commercial genuine, intermediate grade	54.00
Anti-friction metal, general service	31.50
No. 4 babbitt (f.o.b.)	12.75

COLD DRAWN STEEL—Shafting and screw stock, warehouse prices per 100 lb., base, are as follows:

	New York	Cleveland	Chicago
Round or hexagon	$3.50	$3.65	$3.60
Flat or square	4.00	4.15	4.10

BOILER FITTINGS—F.o.b. warehouse, Jersey City, N. J., discounts from list:

Copper ferrules	70%
Boiler flanges	65-5%
Boiler stay bolts	60%
Boiler patch bolts	20%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following discounts from list are for large mill lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv
1 to 3	62%	50½%	1 to 1½	30%	13%

LAP WELD

2	55%	43½%	2	23%	7%
2½ to 6	59%	47½%	2½	26%	11%
7 and 8	56%	43½%	3 to 6	28%	13%
9 and 10	54%	41½%	7 to 12	26%	11%
11 and 12	53%	40½%			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60%	49½%	1 to 1½	30%	14%
2 and 3	61%	50½%			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53%	42½%	2	23%	9%
2½ to 4	57%	46½%	2½ to 4	29%	15%
4½ to 6	56%	45½%	4½ to 6	28%	14%
7 and 8	52%	39½%	7 and 8	21%	7%
9 and 10	45%	32½%	9 to 12	16%	2%
11 and 12	44%	31½%			

BOILER TUBES—Following are net prices per 100 ft. at New York warehouses on tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17.07
1¼	.....	.....	19.20
1½	.....	$38.00	17.92
1¾	.....	28.50	20.48
2	$17.33	25 00	20.24
2¼	19 84	28 25	23 00
2½	21 60	34 00	26 03
3	25.50	42 50	27.04
3¼	30.25	49 50	30 67
3½	31.50	52 75	33 33
4	38.03	67.00	40.11

These prices are net, per 100 ft., based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

2 in. and smaller.. 5c. per cut. 3 in..... 9c. per cut.
2¼ and 2½ in.... ..6c. per cut. 3½ to 4 in.... 10c. per cut.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent. 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$31.50 (net)	$45.00 (net)	$180.00	$220.00
No. 12 solid	136.00	180.00	225.00	275.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	305.00	375.00	420.00	500.00
No. 6 stranded	440.00	530.00	615.00	.....

From the above lists discounts are:	Lead Covered
Less than coil lots	30%
Coils to 1,000 ft	35%
1,000 to 5,000 ft	38%
5,000 ft. and over	40%

CONDUIT—Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, per 100 pieces, extra f.o.b. New York warehouse. Discount of 5 per cent. for payment in 10 days. Delivery charges, approximately 5 per cent. additional; 10,000 lbs. and over delivered free.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
½	72.07	78.63	10.21	11.62	6.46	7.03
1	103.31	113.00	15.10	17.21	8.39	9.13
1¼	139.77	152.88	20.51	23.07	11.78	12.75
1½	167.12	182.79	27.34	30.76	14.56	15.75
2	224.85	245.94	50.13	56.40	19.41	21.01
2½	355.50	388.85	82.03	92.28	27.73	30.01
3	464.88	508.50	218.74	246.10	41.59	45.01
3½	585.30	637.74	483.04	543.46	55.46	60.02
4	714 17	776.30	558.23	628.06	69.32	75.02

ONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices, each, in standard-package quantities:

CUT-OUTS, PLUG, SOLID, NEUTRAL OR 2-FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID, NEUTRAL OR 2-FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$21.50
No. 16 cotton reinforced heavy		25.00
No. 18 cotton reinforced light		15.50
No. 16 cotton reinforced light		22.00
No. 18 cotton Canvasite cord		17 00
No. 16 cotton Canvasite cord		27.00
No. 16 super service cord or similar (2 wire) in 1,000 ft	$70.80	*76 70
No. 14 super service cord or similar (2 wire) in 1,000 ft	106.20	*115.05

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30 amp,	100	$0.15	3-amp. to 30-amp.,	100	$0.30
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
61-amp to 100 amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
101-amp to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
201-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
401-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less than one-fifth standard package, 60%; one-fifth to standard package, 65%; standard package, 70%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30-amp.	$0.03 ea.	$0.05	100	100
35 to 60-amp.	.05 ea.	.06	100	100
65 to 100-amp.	.10 ea.	.10	50	50
110 to 200-amp.	.15 ea.	.15	25	50
225 to 400-amp.	.30 ea.	.30	25	25
450 to 600-amp.	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken cartons	Net
Unbroken cartons	22%
Ten unbroken cartons	40%
Discount Without Contract—Renewals:	
Broken cartons	Net list
Unbroken cartons	22%
Ten unbroken cartons	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons	26%
Ten unbroken cartons	42%
Discount With Contract—Renewals:	
Broken cartons	Net list
Ten unbroken cartons	42%

Carton quantities may be combined to obtain maximum discounts.

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.80
0-30 ampere, less than standard package	3.10

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard, A type bulbs:

100—130 Volt General Watts	Type	Price Each	200—260 Volt Special Watts	Type	Price Each
15	A 17	$0.20	25	A 19	$0.25
25	A 19	.20	50	A 21	.25
40	A 21	.20	100	A 23	.45
50	A 21	.20	....	....	....
60	A 21	.20	....	....	....
100	A 23	.35	....	....	....

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net, allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain, separable, attachment plug	$0.18
Composition, 2-piece, attachment plug	.27
Swivel attachment plug	.12
Small size, 2-piece plug, composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Solid Duplex
14	$7.70	$10.40	$12.70	$21.00
12	11.60	13.40	15.90	28.00
10	15.70	17.90	21.00	37.50
8	23.10	26.20	27.75	53.00
6	.....	.....	40.00	....
4	.....	.....	58.00	....
2	.....	.....	81.00	....
1	.....	.....	105.00	....
0	.....	.....	129.00	....
00	.....	.....	150.00	....
000	.....	.....	184.00	....
0000	.....	.....	225.00	....

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap Key	½ In. or Pendant Cap Keyless	½ In. or Pendant Cap Pull	½ In. Cap Key	½ In. Cap Keyless	½ In. Cap Pull
Standard package	$0.12	$0.10	$0.16	$0.16½	$0.14	$0.20
Unbroken carton	.14	.12	.18	.18	.16	.21
Broken carton	.16	.14	.20	.20	.18	.24

WIRING SUPPLIES—

Friction tape, ¾ in., less than 100 lb., 31c. per lb.	100 lb. lots	29c. per lb.
Rubber tape, ¾ in., less than 100 lb., 33c. per lb.	100 lb. lots	31c. per lb.
Wire solder, less than 100 lb., 33c. per lb.	100 lb. lots	31c. per lb.
Soldering paste, 2 oz. cans		$1.10 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 .00 to $50.00 list value	35%
$50.00 list value or over	40%